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EPA System Requirements and Design for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® version 1.1

Prepared for

The Technical Review Workgroup for Metals and Asbestos (TRW)

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U.S. Environmental Protection Agency
Technical Review Workgroup for Metals and Asbestos

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Table of Contents

Disclaimer ii

Members iii

Table of Contents v

List of Tables vii

List of Figures ix

1.0 Introduction 1
1.1 Purpose 1
1.2 Background 1
1.3 Scope 1
1.4 Approach 2
1.5 System References 3
1.6 Terms and Abbreviations 3
1.7 Referenced Documents 4
1.8 Organization of This Document 5

2.0 System Requirements 7
2.1 System Definition 7
2.1.1 System Concept and Purpose 7
2.1.2 System Sizing and Timing Requirements 7
2.1.3 Design Standards 7
2.1.4 Design Constraints and Assumptions 7
2.2 System Hardware and Software Requirements 8
2.3 Functional Requirements 8
2.3.1 Exposure Component 14
2.3.1.1 Air Lead Exposure Module 14
2.3.1.2 Dietary Lead Exposure Module 15
2.3.1.3 Water Lead Exposure Module 18
2.3.1.4 Soil Lead Exposure Module 19
2.3.1.5 Dust Lead Exposure Module 20
2.3.1.6 Exposure Component Parameters 23
2.3.2 Uptake Component 30
2.3.3 Biokinetic Component 32
2.3.4 Probability Distribution Component 33

3.0 Software Detail Design 35
3.1 Overall Design Description 35
3.1.1 Local Data 35
3.1.2 Control 35
3.1.3 Error Handling 35
3.1.4 Data Conversion 36
3.1.5 Test Structure 36
3.1.6 Manual Procedures 36
3.2 Exposure Component 36

3.2.1 Air Lead Exposure Module 37
3.2.2 Dietary Lead Exposure Module 38
3.2.3 Water Lead Exposure Module 39
3.2.4 Soil/Dust Lead Exposure Module 40
3.2.5 Maternal Lead Exposure Module 41
3.2.6 Other Lead Exposure Module 41
3.2.7 GI/Bioavailability Module 42
3.3 Uptake Component 42
3.4 Biokinetic Component 42

4.0 Documentation for the IEUBKwin 43

List of Tables

Table 1. Terms and Abbreviations 4
Table 2. Values for the new consumption variables that were added to version 1, build 264..... 17

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List of Figures

Figure 1. System Life Cycle 3
Figure 2. Biological Structure of the IEUBKwin Model. 9
Figure 3. Mathematical Structure of the IEUBKwin Model.. 10
Figure 4. Iterative Procedure for Determining Compartmental Lead Masses in Biokinetic Component. 13

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1.0 Introduction

1.1 PURPOSE

This System Requirements and Design document is an all-inclusive synopsis of the requirements for the development of the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). It documents the design and implementation of the software, and is intended as a reference which can be used in the future for model enhancement or modification. The requirements portion of this document describes, in detail, the parameters and equations that are used in the IEUBKwin model. The design portion describes the structure and details of the design of the model.

1.2 BACKGROUND

The IEUBK model is a standalone, personal computer (PC)-compatible software package. The model allows the user to estimate a plausible distribution of blood lead concentrations for a hypothetical child or population of children. This distribution is centered on the geometric mean blood lead concentration which is predicted from available information about the child and his/her exposure to lead. From this distribution, the model estimates the probability that a child's blood lead concentration will exceed a certain level of concern (either user-selected or default). The user also can explore possible changes in exposure media that would alter the probability that blood lead concentrations would be above this level.

The model should be viewed as a tool for making rapid calculations and recalculations of an extremely complex set of equations that include exposure, uptake, and biokinetic parameters. The model was originally developed as a tool for determining site-specific cleanup levels. The Office of Solid Waste and Emergency Response (OSWER) hopes to base the U.S. Environmental Protection Agency (EPA) lead guidance, directives (*e.g.*, the Lead Directive), and future rulemaking on the results produced by the IEUBK model. The IEUBK model has been recommended as a risk assessment tool to support the implementation of the July 14, 1994, OSWER *Interim Directive on Revised Soil Lead Guidance for CERCLA Sites and RCRA Facilities*. The model uses four interrelated components (exposure, uptake, biokinetics, and probability distributions) to estimate blood lead levels in children exposed to contaminated media.

1.3 SCOPE

This System Requirements and Design document encompasses both the intent and purpose of the IEUBK model as well as the programming details, documenting all facets of the program. Rather than incorporate duplicative material, this document references additional sources of information about the model. This document is not intended as a user's guide, which is available as standalone document.

1.4 APPROACH

This document represents a particular step in the information system life cycle. As stated in the *OSWER System Life Cycle Management Guidance* (April 1988):

> "Life cycle management represents a structured approach to solving an information management problem ... starting with the initial identification of the problem, progressing through the building or acquisition of a solution, and ending with the final disposition of the solution at the end of its useful life."

Figure 1 illustrates the five major phases and the stages of the system life cycle which are as follows:

- Initiation
- Concept
- Definition and Design
- Development and Implementation (including testing)
- Operation (stages include production, evaluation, and archive)

The OSWER System Life Cycle is designed to allow flexibility in system development while at the same time providing distinct steps to follow in each phase. Each step has clearly defined:

- Objectives (major accomplishments)
- Key decisions (related to project approach, project execution, and project continuation)
- Products (primarily documentation, but can include other written material and the system itself)

The *OSWER System Life Cycle Management Guidance* includes descriptions of each phase and discussion of the various steps involved in the phase. Outlines are provided for the system documentation requirements which are included in the products within each phase.

In reference to the IEUBK model, the life cycle began with system conception and included system design, development, and implementation. Currently, the IEUBKwin model is in the operation stage, in which the system definition, design, development, and implementation phases are repeated.

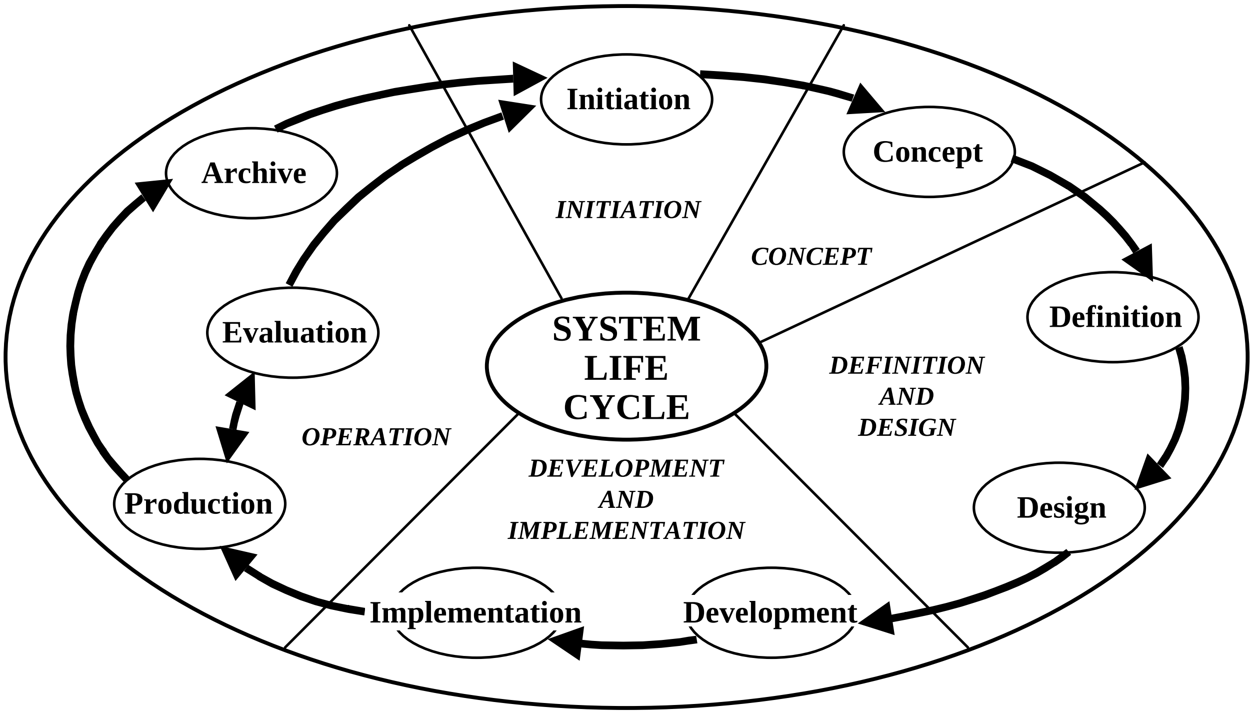

Figure 1. System Life Cycle

1.5 SYSTEM REFERENCES

The primary reference for the IEUBKwin model version 1.1 is earlier versions of the IEUBK model software (versions 0.99d and version 1.0). References include the U.S. EPA documents listed in Section 1.7.

1.6 TERMS AND ABBREVIATIONS

A number of terms, acronyms, and abbreviations are used throughout this document. Acronyms and abbreviations are identified in parentheses following the first usage of the term. Terms and abbreviations used often in this document are listed in the table below:

Table 1. Terms and Abbreviations

TERM	ABBREVIATION
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA
cubic meters	m^3
Disk Operating System	DOS
deciliter	dL
Environmental Protection Agency	EPA
gastrointestinal	GI
gram	g
Independent Verification and Validation	IV&V
Integrated Exposure Uptake Biokinetic Model for Lead in Children	IEUBK
Integrated Exposure Uptake Biokinetic Model for Lead in Children Windows version	IEUBKwin
liters	L
micro	µ
Office of Solid Waste and Emergency Response	OSWER
Resource Conservation and Recovery Act	RCRA
lead	Pb
Technical Review Workgroup for Lead	TRW
Technical Support Document	TSD

1.7 REFERENCED DOCUMENTS

The documents listed below served as references for developing the IEUBKwin model.

- *Correspondence between the IEUBK Lead Model Source Code and Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic Model for Lead in Children (version 0.99d)*, prepared by Battelle for EPA Office of Pollution Prevention and Toxics, September 30, 1994.

- *EPA System Design and Development Guidance*, June 1989.

- *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, Publication Number, 9285.7-15-1, EPA/540/R-93/081, PB93-963510, February 1994.

- *Phase I Report for the Independent Verification and Validation (IV&V) of the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children*, Vols. I and II, prepared by SAIC for EPA Office of Solid Waste and Emergency Response, November 3, 1995.

- Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (version 0.99d), Publication Number 9285.7-22, EPA 540/R-94/040, PB 94-963505, December 1994.

- OSWER System Life Cycle Management Guidance. OSWER 9028.00, April 1988.

In addition to the documents listed above, the TRW Lead Committee web site has guidance and recommendations pertinent to lead risk assessment for hazardous waste sites (www.epa.gov/superfund/lead).

1.8 ORGANIZATION OF THIS DOCUMENT

This document is divided into the following five chapters with four appendices:

1.0 Introduction
2.0 System Requirements
3.0 Software Detailed Design
4.0 Documentation for the IEUBKwin

Appendix A Equations and Parameters in the IEUBKwin Model
Appendix B Data Crosswalk for the IEUBKwin Model
Appendix C IEUBKwin Parameter Dictionary

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2.0 System Requirements

2.1 SYSTEM DEFINITION

In terms of functionality, the IEUBKwin model is essentially the same as earlier versions of the model (version 0.99d and version 1.0). The primary difference is that the IEUBKwin model version 1.1 incorporates updates to several model variables (i.e., dietary data and maternal blood lead concentration) and addresses a discrepancy with the equations used to fit the bone growth data (to a single continuous equation). As this task was solely a conversion effort, no attempt was made to modify the program code substantively.

2.1.1 System Concept and Purpose

In order to predict the likely distribution of blood lead concentrations for children between the ages of 6 months and 7 years exposed to lead in environmental media, the IEUBKwin model combines estimates of lead intake from lead in air, water, soil, dust, diet, and other ingested environmental media with an absorption model for the uptake of lead from the lung or gastrointestinal tract, and a biokinetic model of lead distribution and elimination from a child's body.

2.1.2 System Sizing and Timing Requirements

The IEUBKwin model is a standalone program that must be capable of performing on a desktop personal computer. For easy distribution and installation, the system should be able to be downloaded via the Internet.

2.1.3 Design Standards

The design standards from the *EPA System Design and Development Guidance* June 1989 were followed in developing the IEUBK. In addition the changes to IEUBKwin version 1.1 were made according to the Capability Maturity Model Implementation (CMMI). CMMI is an evaluation tool used by government contractors to perform a contracted software project. At the time of development, the contractor developing the software was at CMM level 3. The CMM Level 3 credential demonstrates that SRC's software engineering solutions establish consistency across the organization, which enables result-oriented outcomes for SRC staff and customers.

2.1.4 Design Constraints and Assumptions

EPA required that the IEUBKwin model be portable. Consequently, it was important to efficiently recode the IEUBKwin model. This feature makes distribution of the model both inexpensive and easy. The compiler program, Visual C++ version 6.0, was selected as the development tool. This feature makes the IEUBKwin model portable in selected 32-bit Windows environments (Windows 98/ME, Windows 2000, and Windows NT).

2.2 SYSTEM HARDWARE AND SOFTWARE REQUIREMENTS

The IEUBKwin model is designed to operate on a specific hardware platform with one of a limited number of operating systems installed. The optimal hardware and software requirements are shown below.

Recommended for Optimum Performance:
- Pentium Processor
  - 200 MHZ (or higher)
  - 32MB RAM
  - 10MB Disk space
  - 32-bit Windows Operating System

2.3 FUNCTIONAL REQUIREMENTS

Figures 2 and 3 are graphical illustrations of the biological and mathematical structures, respectively, of the IEUBKwin model. The biological structure in Figure 2 shows how lead can move from the environment of a hypothetical child into the child's blood, while the mathematical structure in Figure 3 shows the parameters and calculations necessary to determine the child's blood lead concentration. Exposure, uptake, and biokinetic components are clearly delineated in the figures and correspond to functions of the IEUBKwin model. Each of these components, plus a fourth component—Probability Distribution—is briefly described below. Beginning in Section 2.3.1, each of the components is described in more detail, from a functional perspective. For each component, these later sections address its purpose, the functions performed in terms of the mathematical equations involved, and the interface between that component and the others.

Descriptions of the database used by each component are not included in these sections because neither the model components nor the IEUBKwin model use separate databases. Refer to the IEUBKwin model Parameter Dictionary for details about the database. Similarly, a network interface for the components is not addressed; the components are contained within an overall program that is implemented as a standalone system.

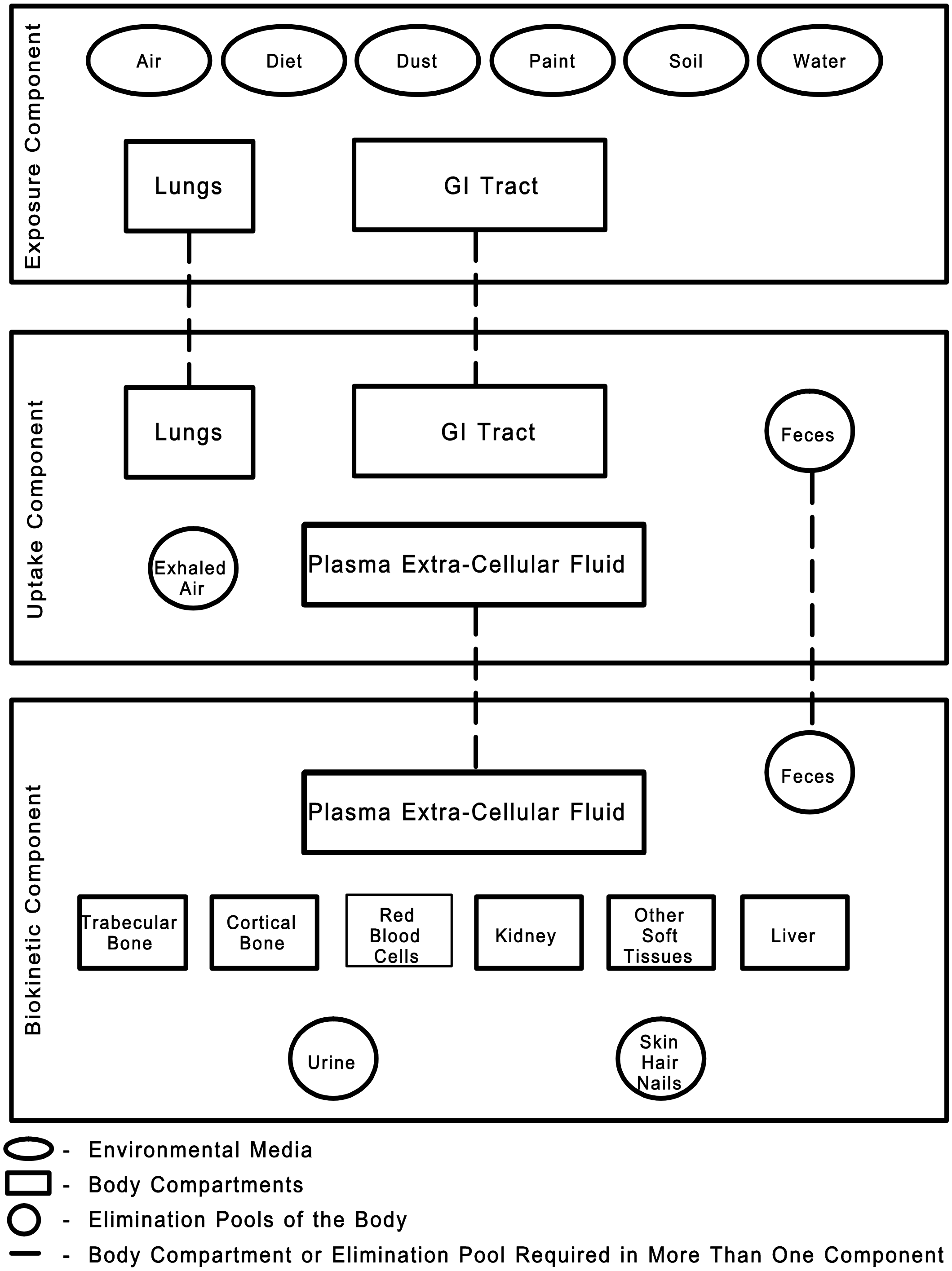

Figure 2. Biological Structure of the IEUBKwin Model.

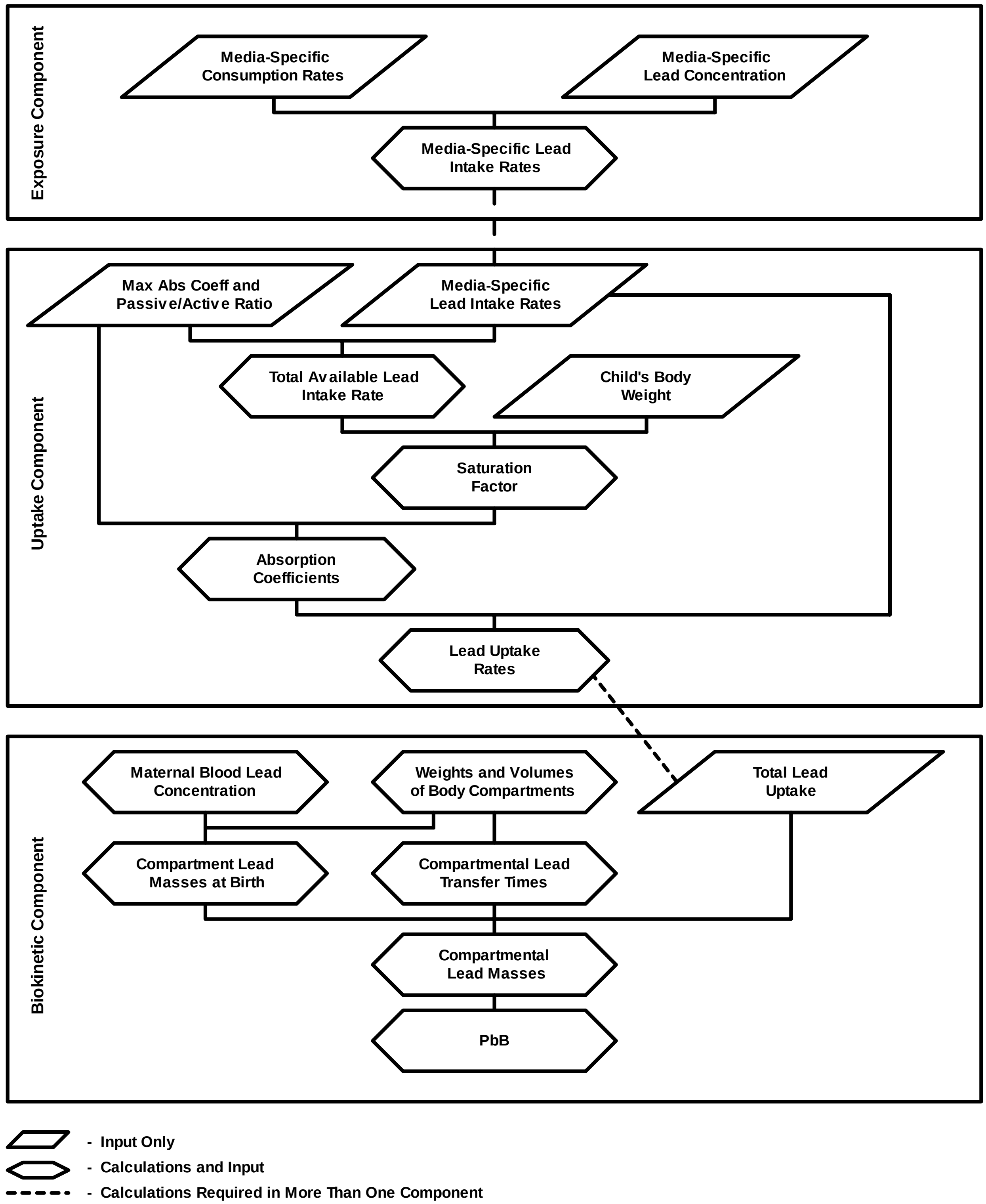

Figure 3. Mathematical Structure of the IEUBKwin Model.

Exposure Component

As indicated in Figure 2, the exposure component relates environmental lead concentrations to the intake rate at which lead enters the child's body via the gastrointestinal (GI) tract and lungs. The environmental media that serve as lead sources for the child are air, which enters the body through the lungs, and diet, dust, paint, soil, water, and other media which enter the body through the GI tract. As indicated in Figure 3, the exposure component converts media-specific consumption rates (in m^3/day, g/day, or L/day) and media-specific lead concentrations (in µg Pb/m^3, µg Pb/g, µg Pb/L), to media-specific lead intake rates (in µg Pb/day). The media-specific consumption rates and lead concentrations can be modified by the user using site specific data. The general equation relating the consumption rates and lead concentrations to the lead intake rate is:

$$\textit{Lead Intake Rate} = \textit{Media Lead Concentration} * \textit{Media Intake Rate}$$

In this manner, the exposure component determines how much lead enters the child's body and stores that information in a set of media-specific lead intake rates.

Uptake Component

As indicated in Figure 2, the uptake component relates lead intake into the lungs or GI tract determined in the exposure component to the uptake of lead from the exposed membrane into the child's blood, for children at each age. Lead that enters through the lungs is either absorbed into the blood plasma through the lungs, transferred to the GI tract, or eliminated from the body via exhaled air. Very small particles may move directly into the blood plasma or may be eliminated from the body via exhaled air. Most of the lead found in the human body enters through the GI tract, either through direct ingestion or by movement from the nose, throat or lung structures. Lead that enters the body through the GI tract is either absorbed into the blood plasma or eliminated from the gut with other waste as feces. As indicated in Figure 3, the uptake component converts the media-specific lead intake rates produced by the exposure component into media-specific lead uptake rates (µg/day) for the blood plasma.

The total lead uptake (µg/day) from the GI tract is estimated as the sum of two components, one passive (represented by a first order, linear relationship), the second active (represented by a saturable, nonlinear relationship). These two components are intended to represent two different mechanisms of lead absorption, an approach which is in accord with the limited data available in humans and animals, and also by analogy, with what is known about calcium uptake from the gut. First, the total lead "available" for uptake from the gut is defined as the sum, across all media, of the media-specific intake rate multiplied by the estimated low-dose fractional absorption for that medium. A passive absorption coefficient defines the dose-independent fraction of the available lead that is absorbed by the passive absorption pathway, and allows calculation of the rate of absorption via that pathway. The rate of absorption of the remaining available lead by the active pathway is calculated using a non-linear relationship that allows for saturable absorption.

Biokinetic Component

As indicated in Figure 2, the biokinetic component models the transfer of absorbed lead between blood and other tissues, or elimination of lead from the body via urine, feces, skin, hair, and nails. The biokinetic component of the IEUBK model is structured as a compartmental model of the human body with transfer times between compartments as basic model building elements. The compartmental structure of the IEUBK model was developed by identifying the anatomical components of the body critical to lead uptake, storage, and elimination, and the routes or pathways between these compartments. This compartmental scheme includes a central body compartment, six peripheral body compartments, and three elimination pools. The blood plasma is combined with the body's accessible extracellular fluid (ECF) to form the central plasma/ECF body compartment. Separate body compartments are used to model the trabecular bone, cortical bone, red blood cells, kidney, and liver. The remainder of the body tissues is included in the "other soft tissues" peripheral body compartment. Three elimination pathways are included in the biokinetic model: pathways from the central plasma/ECF compartment to the urinary pool, from the compartment for other soft tissues to skin, hair, and nails, and from the liver to the feces.

As indicated in Figure 3, the biokinetic component converts the total lead uptake rate produced by the uptake component into an input to the blood plasma/ECF. Transfer coefficients are used to model movement of lead between internal compartments and to the excretion pathway. These quantities are then combined with the total lead uptake rate to determine lead masses in each of the body compartments. The lead in the plasma portion of the central/ECF compartment is added to the lead in the red blood cells to determine the blood lead concentration.

The iterative nature of the calculations in the biokinetic component is illustrated in Figure 4. The period of exposure, 0 to 84 months, is divided into a number of equal time steps (within the range of 15 minutes to one month) that are set by the user. During each iteration, compartmental lead masses at the beginning of a time step are combined with the total lead uptake, inter-compartmental transfers, and quantities of excretion during the time step to estimate compartmental lead masses at the end of the time step. The compartmental lead transfer times during the time step are key parameters in these calculations. The compartmental lead masses at the end of the time step then become the compartmental lead masses at the beginning of the next time step and the iterative process continues. The iterative process is initiated by determining the compartmental lead masses at birth from the maternal blood lead concentration and data on the relative concentrations of lead in different tissues of stillborn fetuses. The model calculates all of the compartmental contents from 0 to 84 months; and reports blood lead concentrations from 6 to 84 months.

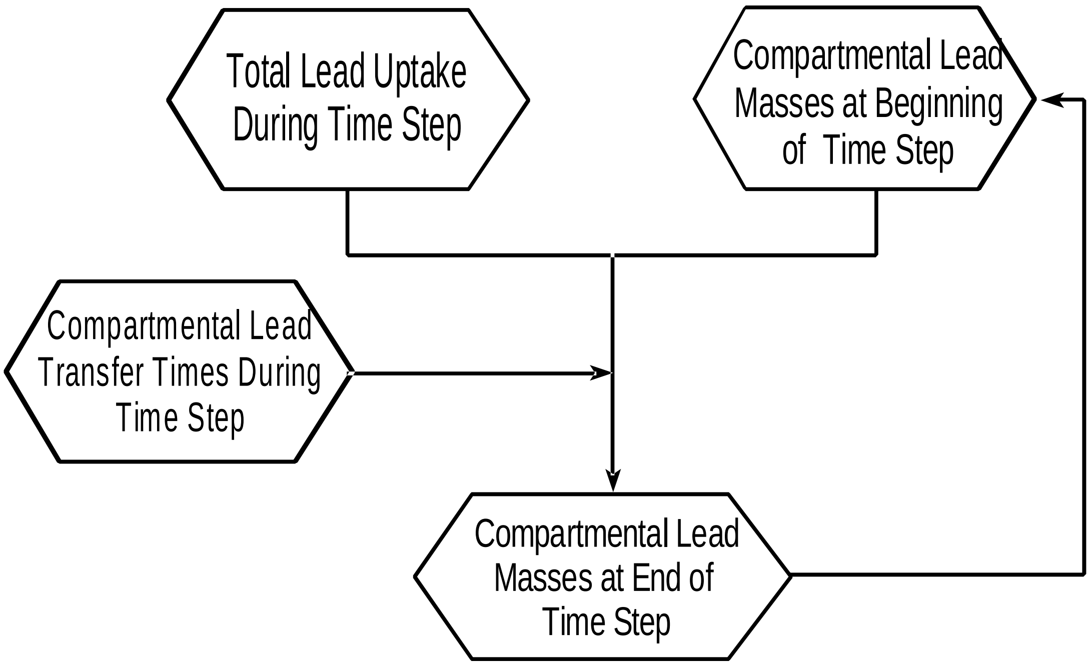

Figure 4. Iterative Procedure for Determining Compartmental Lead Masses in Biokinetic Component.

Probability Distribution Component

The probability distribution component of the model estimates a plausible distribution of blood lead concentrations. The distribution is centered on the geometric mean blood lead concentration for a hypothetical child or population of children. The distribution can be displayed graphically, or the data can be downloaded into another software program for statistical analysis. Descriptive statistics and Plot/Graph are functions of PBSTAT, which uses files with the "*.asc" extension, which are generated from the DOS IEUBK model. To use these functions in the Windows batch mode data, files which have the extension "*.txt", must be renamed with the file extension to "*.asc" using File Manager or Windows Explorer. The *Batch Mode* text results file (*.txt) generated from the IEUBKwin model can be used in the DOS version of PBSTAT by renaming the file extension from *.txt to *.asc in File Manager or Windows Explorer. Note that the *.asc file generated by IEUBKwin will have to be modified for PBSTAT: all the headers must be removed except for the ID FAM BLK line; The P (PbB>C) data column must also be removed; the data should begin on line 4.

2.3.1 Exposure Component

The exposure component of the IEUBKwin model converts media-specific consumption rates and media-specific lead concentrations to media-specific lead intake rates. The media that are included in the exposure component are air, diet, water, soil, dust and paint. The equations that govern these model calculations are listed and discussed below.

In these equations, the lead intake rates for air, diet, household dust, alternate source dust, soil, water, and other ingested media are denoted by INAIR[AGE], INDIET[AGE], INDUST[AGE], INDUSTA[AGE], INSOIL[AGE], INWATER[AGE], and INOTHER[AGE], respectively. The notation "[AGE]" indicates that these intake rates change with the age, t, of the child. All lead intake rates are in units of g Pb/day. Once calculated, media-specific lead intake rates serve as inputs to the uptake component. In the sections below, the calculations required to determine the lead intake rates are discussed by media.

2.3.1.1 Air Lead Exposure Module

The air lead exposure module considers both indoor and outdoor air lead exposure for determining the child's overall air lead exposure. The outdoor air lead concentration [air_concentration[AGE]] is specified by the user. The indoor air lead concentration [IndoorConc[AGE]] is determined according to Equation E-1 as a user-specified, constant percentage [Indoorpercent] of the outdoor air lead concentration. A time-weighted average air lead concentration [TWA[AGE]] is determined according to Equation E-2 where the indoor and outdoor air lead concentrations are weighted by the user-specified, age-dependent number of hours per day that a child spends outdoors [time_out[AGE]]. Finally, the lead intake from air, INAIR[AGE], is calculated according to Equation E-3 as the product of the time-weighted air lead concentration and a user-specified, age-dependent ventilation rate [vent_rate[AGE]].

$$IndoorConc[AGE] = 0.01 * indoorpercent * air\_concentration[AGE] \quad \text{(E-1)}$$

$$TWA[AGE] = \frac{[time\_out[AGE] * air\_concentration[AGE]] + [24 - (time\_out[AGE]) * IndoorConc[AGE]]}{24} \quad \text{(E-2)}$$

$$INAIR[AGE] = TWA[AGE] * vent\_rate[AGE] \quad \text{(E-3)}$$

2.3.1.2 Dietary Lead Exposure Module

Dietary lead exposure, or the lead intake rate from diet [INDIET[AGE]], is determined by one of two methods: (1) direct specification, or (2) the alternative diet model. Under direct specification, INDIET[AGE] is set equal to a user-specified, age-dependent lead intake rate for diet [diet_intake[AGE]], as indicated in Equation E-4a:

$$INDIET[AGE] = diet\_intake[AGE] \quad \text{(E-4a)}$$

Under the alternative diet model, INDIET[AGE] is calculated as the sum of the lead intake rates for meat, vegetables, fruit, and other sources. The first three categories are sub-divided as follows:

- Meat
  – non-game animal (InMeat[AGE])
  – game animal (InGame[AGE])
  – fish (InFish[AGE])

- Vegetables
  – canned (InCanVeg[AGE])
  – fresh (InFrVeg[AGE])
  – home-grown (InHomeVeg[AGE])

- Fruit
  – canned (InCanFruit[AGE])
  – fresh (InFrFruit[AGE])
  – home-grown (InHomeFruit[AGE])

INDIET[AGE] = DietTotal[AGE] = InMeat[AGE] + InGame[AGE] + InFish[AGE] + InCanVeg[AGE] + InFrVeg[AGE] + InHomeVeg[AGE] + InCanFruit[AGE] + InFrFruit[AGE] + InHomeFruit[AGE] + InOtherDiet[AGE][1] (E-4b)

InOtherDiet[AGE] = InDairy[AGE] + InJuice[AGE] + InNuts[AGE] + InBread[AGE] + InPasta[AGE] + InBeverage[AGE] + InCandy[AGE] + InSauce[AGE] + InFormula[AGE] + InInfant[AGE] (E-4c)

Under the alternative diet intake calculation, each of the terms of Equations E-4b and E-4c are calculated as the product of the lead concentration for that food category and the food consumption rate for that category, as shown in Equations E-4d through E-4r.

beverage[AGE] = beverageConc * beverage_Consump[AGE] (E-4d)
bread[AGE] = breadConc * bread_Consump[AGE] (E-4e)
can_fruit[AGE] = canFruitConc * canFruit_Consump[AGE] (E-4f)
can_veg[AGE] = canVegConc * canVeg_Consump[AGE] (E-4g)
candy[AGE] = candyConc * candy_Consump[AGE] (E-4h)
dairy[AGE] = dairyConc * dairy_Consump[AGE] (E-4i)
f_fruit[AGE] = fFruitConc * fFruit_Consump[AGE] (E-4j)
f_veg[AGE] = fVegConc * fVeg_Consump[AGE] (E-4k)
formula[AGE] = formulaConc * formula_Consump[AGE] (E-4l)
infant[AGE] = infantConc * infant_Consump[AGE] (E-4m)
juices[AGE] = juiceConc * juice_Consump[AGE] (E-4n)
meat[AGE] = meatConc * meat_Consump[AGE] (E-4o)
nuts[AGE] = nutsConc * nuts_Consump[AGE] (E-4p)
pasta[AGE] = pastaConc * pasta_Consump[AGE] (E-4q)
sauce[AGE] = sauceConc * sauce_Consump[AGE] (E-4r)

The within-age sum of the dietary lead intake variables[1], which are defined by Equations E-4d through E-4r, equal the default dietary lead intake represented by diet_intake[AGE]. The values for the concentration and consumption rate parameters that appear in E-4d through E-4r are assigned in the code and are not accessible to the user. The values for concentration are based on the TRW's analysis of the Food and Drug Administration (FDA) total diet study data from market basket samples that were collected from 1995-2003 (FDA, 2006). The values for consumption were derived from the food concentration values that appeared (but were not used) in the IEUBK DOS model (v. 0.99d) code, and the values of the food intake parameters that were used in the IEUBK Windows model code up to Version 1.0, Build 263.

[1] The values for the dietary lead intake variables were formerly assigned directly in the code in Version 1.0, Build 263 and earlier versions, including the DOS versions. In Windows Version 1.0, Build 264, the concentration and consumption rate parameters that appear in Equation E-4d through E-4r were added to clarify how the values for dietary intake were derived, and to make the code easier to update as new information on food residue concentration and consumption rates become available.

With the exception of InOtherDiet[AGE][2], which only uses default values, the terms on the right-hand side of the equal sign of Equation E-4b are defined in Equations E-5a through E-5l. In Equations E-5a through E-5l the model allows the user to vary local dietary factors (*e.g.,* home grown vegetables, fruits, game animals and fish) that may influence overall lead exposure. The user specifies the fraction of total food category consumption represented by each food source. However, the total quantity of food consumption from each category (meat, vegetables, fruit) is a model constant. Because the total quantity of food consumption for each food category is a constant, it is recommended that users do not make changes to dietary lead intake variables in combination with alternate dietary exposures. In Equations E-5a through E-5e, the traditional supermarket portion of the dietary lead intake rate is calculated as the sum of the products of each consumption fraction and the specific lead intake for that category of food. The consumption fraction is calculated as a complement of the user defined nonsupermarket fraction [*i.e.,* 1 - user defined nonsupermarket fraction]:

meatFraction = 1 – userFishFraction – userGameFraction (E-5a)
vegFraction = 1 – userVegFraction (E-5b)
fruitFraction = 1 – userFruitFraction (E-5c)

InMeat[AGE] = meatFraction * meat[AGE] (E-5d)
InCanVeg[AGE] = vegFraction/2 * can_veg[AGE] (E-5e)
InFrVeg[AGE] = vegFraction/2 * f_veg[AGE] (E-5f)
InCanFruit[AGE] = fruitFraction/2 * can_fruit[AGE] (E-5g)
InFrFruit[AGE] = fruitFraction/2 * f_fruit[AGE] (E-5h)

Table 2. Values for the new consumption variables that were added to IEUBK version 1.1.

	[AGE]						
	1	2	3	4	5	6	7
beverage_Consump[AGE]	87.993	116.487	209.677	194.982	177.061	183.333	188.710
bread_Consump[AGE]	4.992	15.862	13.311	16.639	19.967	22.629	27.898
candy_Consump[AGE]	9.955	11.273	32.909	24.409	16.000	14.818	12.455
canFruit_Consump[AGE]	13.941	8.183	8.145	7.691	7.236	7.460	7.906
canVeg_Consump[AGE]	0.668	2.274	2.563	2.662	2.771	2.626	2.356
dairy_Consump[AGE]	41.784	35.321	38.527	38.327	38.176	40.631	45.591
ffruit_Consump[AGE]	2.495	12.540	11.196	11.196	11.452	12.988	16.059
formula_Consump[AGE]	45.153	22.975	0.797	0.000	0.000	0.000	0.000
fveg_Consump[AGE]	8.773	15.945	28.156	27.623	27.030	29.164	33.373
infant_Consump[AGE]	131.767	66.905	1.634	0.000	0.000	0.000	0.000
juice_Consump[AGE]	2.018	11.656	15.692	15.692	15.692	19.646	27.471
meat_Consump[AGE]	12.500	29.605	38.111	40.930	43.750	47.368	54.558
nuts_Consump[AGE]	0.087	0.962	0.875	0.962	0.962	0.962	0.875
pasta_Consump[AGE]	10.409	18.902	26.263	25.915	25.566	27.134	30.183
sauce_Consump[AGE]	1.647	4.784	5.569	6.902	8.157	8.235	8.235

In Equations E-5i through E-5l, the lead intake rate is calculated as the product of the user-defined nonsupermarket consumption fraction, and a consumption rate for that category of food:

---

[2] For the sake of simplification, the term InOtherDiet[AGE] is used in the text to represent components of the diet other than meat, fruit, vegetables, fish, or game (this term does not actually appear in the code). These other dietary components are modeled as InDairy, InJuice, InNuts, InBread, InPasta, InBeverage, InCandy, InSauce, InFormula, and InInfant. The values for these parameters are defined in the program code for the model and cannot be modified by the user. The values of these parameters are the same whether alternate dietary values are used.

InHomeFruit[AGE] = userFruitFraction * (canFruit_Consump[AGE] + fFruit_Consump [AGE]) * UserFruitConc (E-5i)

InHomeVeg[AGE] = userVegFraction * (canVeg_Consump[AGE] + fVeg_Consump[AGE]) * UserVegConc (E-5j)

InFish[AGE] = userFishFraction * meat_consump[AGE] * UserFishConc (E-5k)

InGame[AGE] = userGameFraction * meat_consump[AGE] * UserGameConc (E-5l)

In Equations E-5m through E-5v, the terms of InOtherDiet[AGE] are defined. All these terms have default values in the model. See Appendix B, the Data Crosswalk for the IEUBKwin model, for the default values.

InDairy[AGE] = dairy[AGE] E-5m

InJuice[AGE] = juices[AGE] E-5n

InNuts[AGE] = nuts[AGE] E-5o

InBread[AGE] = bread[AGE] E-5p

InPasta[AGE] = pasta[AGE] E-5q

InBeverage[AGE] = beverage[AGE] E-5r

InCandy[AGE] = candy[AGE] E-5s

InSauce[AGE] = sauce[AGE] E-5t

InFormula[AGE] = formula[AGE] E-5u

InInfant[AGE] = infant[AGE] E-5v

2.3.1.3 Water Lead Exposure Module

Water lead exposure is determined by one of two methods: (1) direct specification, or (2) an alternative water lead concentration model. For direct specification, as indicated in Equation E-6a, INWATER[AGE] is calculated as the product of a user-specified, age-dependent water consumption rate [water_consumption[AGE]] and a user-specified, constant water lead concentration [constant_water_conc].

INWATER[AGE] = water_consumption[AGE] * constant_water_conc (E-6a)

For the alternative water model, as indicated in Equation E-6b, INWATER[AGE] is calculated as the product of the same user-specified, age-dependent water consumption rate [water_consumption[AGE]] and a constant water lead concentration that is calculated as a weighted average of user-specified, constant water lead concentrations from the first draw on a home faucet [FirstDrawConc], a flushed faucet at home [HomeFlushedConc], and a water fountain outside the home [FountainConc]. These concentrations are weighted by user-specified, constant fractions of consumed water that are first-draw water [FirstDrawFraction], home flushed water [HomeFlushedFraction], and fountain water [FountainFraction]. As indicated in Equation E-7, HomeFlushedFraction is calculated by subtracting the other two fractions from 1.

$$\text{INWATER}\left[\text{AGE}\right] = \text{water\_consumption}\left[\text{AGE}\right] * \begin{pmatrix} \text{HomeFlushedConc * HomeFlushedFraction +} \\ \text{FirstDrawConc * FirstDrawFraction +} \\ \text{FountainConc * FountainFraction} \end{pmatrix} \tag{E-6b}$$

HomeFlushedFraction = 1 – (FirstDrawFraction – FountainFraction) (E-7)

2.3.1.4 Soil Lead Exposure Module

Equation E-8a is used to determine the soil lead exposure for each of the following ‘constant outdoor soil lead concentration’ conditions:

- Multiple source analysis and constant outdoor soil lead concentration
- Variable indoor dust lead concentration and constant outdoor soil lead concentration
- Constant indoor dust lead concentration and constant outdoor soil lead concentration

INSOIL[AGE] = constant_soil_conc[AGE] * soil_ingested[AGE] * (0.01 * weight_soil) (E-8a)

where:

constant_soil_conc[AGE] = the constant user-specified soil lead concentration
soil_ingested[AGE] = the user-specified age-dependent soil and dust ingestion rate
0.01 * weight_soil = a user-specified constant fraction of soil and dust ingested that is soil.

However, if none of the three conditions specified above are applicable, Equation E-8b is used to determine the soil lead exposure. Equation E-8b is only applicable if one of the following ‘variable outdoor soil lead concentration’ conditions exists:

- Multiple source analysis and variable outdoor soil lead concentration
- Variable indoor dust lead concentration and variable outdoor soil lead concentration
- Constant indoor dust lead concentration and variable outdoor soil lead concentration

INSOIL[AGE] =soil_content[AGE]* soil_ingested[AGE] * (0.01 * weight_soil) (E-8b)

where:

soil_content[AGE] = the user-specified age-dependent outdoor soil lead concentration
soil_ingested[AGE] = the user-specified age-dependent soil and dust ingestion rate
0.01*weight_soil = a user-specified constant fraction of soil and dust ingested that is soil

Outdoor soil lead concentration can be specified in an age-dependent manner in the soil/dust data input window.

2.3.1.5 Dust Lead Exposure Module

Dust lead exposure is determined by one of two methods: (1) direct specification, or (2) an alternative dust model. For direct specification, as indicated in Equations E-9a, the baseline dust lead intake, INDUST[AGE], is calculated as the product of a user-specified dust concentration [constant_dust_conc], user-specified age-dependent soil and dust ingestion rate [soil_ingested[AGE]], and the fraction of soil and dust ingestion that is in the form of dust [0.01 * (100 – weight_soil)]. When using the direct specification, the alternative source dust lead intake [INDUSTA[AGE]], is set to zero. Equation E-9a is used if one of the following conditions exists:

- Constant indoor dust lead concentration and constant outdoor soil lead concentration
- Constant indoor dust lead concentration and variable outdoor soil lead concentration

INDUST[AGE] = constant_dust_conc[AGE] * soil_ingested[AGE] * [0.01 * (100 - weight_soil)] (E-9a)

where:

constant_dust_conc[AGE]	= the user-specified dust lead concentration
soil_ingested[AGE]	= the user-specified, age-dependent soil and dust ingestion rate
[0.01 * (100 - weight_soil)]	= the fraction of soil and dust ingestion that is in the form of dust

The alternative dust sources component has two specifications:

- The indoor dust lead concentration is calculated as a sum of contributions from soil and air, either constant or age-dependent (specific calculations are not shown here, please refer to the Appendix A).

- The indoor dust lead intake [INDUSTA[AGE]] is calculated as the sum of contributions from several additional sources as indicated by Equation E-9c. Only a fraction of dust lead exposure is assumed to come from residential dust. When data are available, the remainder of the dust lead is assumed to come from separately estimated dust sources including:

  -Secondary exposure to leaded dust carried home from the workplace [OCCUP[AGE]]
  -Leaded dust at school or pre-school [SCHOOL[AGE]]
  -Leaded dust at other non-school daycare facilities [DAYCARE[AGE]]
  -Leaded dust from secondary homes (*e.g.*, grandparents) [SECHOME[AGE]]
  -Leaded dust from deteriorating interior paint [OTHER[AGE]]

Equations E-9b and E-9c are used in determining the household indoor dust lead concentration [INDUST[AGE]] and alternative indoor dust lead intake [INDUSTA[AGE]] if multiple source analysis and alternate indoor dust lead sources are used.

INDUST[AGE] = DustTotal[AGE] * (soil_indoor[AGE] * HouseFraction) (E-9b)

INDUSTA[AGE] = OCCUP[AGE] + SCHOOL[AGE] + DAYCARE[AGE] + SECHOME[AGE] + OTHER[AGE] (E-9c)

In Equation E-9b, INDUST[AGE] is the product of the age-dependent dust ingestion rate [DustTotal[AGE]] (see Equation E-10), an age-dependent indoor household dust lead concentration [soil_indoor[AGE]] (see Equation E-11a), and the fraction of dust exposure that is from residential dust [HouseFraction] (see Equation E-9.5).

The following equations are used to determine the household indoor dust lead intake and alternative indoor dust lead intake if one of the following conditions exists:

- Multiple source analysis and constant outdoor soil lead concentration
- Multiple source analysis and variable outdoor soil lead concentration

INDUST[AGE] = soil_indoor[AGE] * soil_ingested[AGE] * [0.01 * (100 - weight_soil)] (E-9d)

where:
soil_indoor[AGE] is derived from either Equation E-11a or E-11b
soil_ingested[AGE] is derived from either Equation E-11a or E-11b
[0.01 * (100 – weight_soil)] = the fraction of soil and dust ingestion that is in the form of dust

In Equation E-10, Dust_Total[AGE] is the product of an age-dependent soil and dust ingestion rate [soil_ingested[AGE]] and the user-specified constant fraction of soil and dust ingested that is dust [0.01 * (100 - weight_soil)].

DustTotal[AGE] = soil_ingested[AGE] * [0.01 * (100 - weight_soil)] (E-10)

Equation E-11 has many variations depending on the conditions that exist. In Equation E-11a, soil_indoor[AGE] is calculated as a sum of contributions from soil and air.

soil_indoor[AGE] = (contrib_percent *soil_content[AGE]) + (multiply_factor * air_concentration[AGE]) (E-11a)

The contribution from soil is the product of a user-specified, constant ratio of dust to soil lead concentrations [contrib_percent] and the user-specified, age-dependent outdoor soil lead concentration [soil_content[AGE]]. Similarly, the contribution from air is the product of a user-specified, constant ratio of dust to air lead concentrations [multiply_factor] and the user-specified, age-dependent outdoor air concentration [air_concentration[AGE]]. This equation only applies if both multiple source analysis and variable outdoor soil lead concentration is used in determining INDUST[AGE].

Equation E-11b is applicable if both multiple source analysis and constant outdoor soil lead concentration are used. The parameter constant_soil_conc[AGE] replaces the parameter soil_content[AGE] and uses the default value for outdoor soil lead concentration instead of a user-specified value.

soil_indoor[AGE] = (contrib_percent * constant_soil_conc[AGE]) +
(multiply_factor * air_concentration[AGE]) (E-11b)

Equation E-9e applies if one of the following conditions exists:

- Variable indoor dust lead concentration and constant outdoor soil lead concentration
- Variable indoor dust lead concentration and variable outdoor soil lead concentration

INDUST[AGE] = dust_indoor[AGE] * soil_ingested[AGE] * (0.01 * (100 - weight_soil)) (E-9e)

where:

dust_indoor[AGE]	= the user-specified age-dependent indoor dust concentration
soil_ingested[AGE]	= the user-specified age-dependent soil and dust ingestion rate
(0.01 * (100 - weight_soil))	= the fraction of soil and dust ingestion that is in the form of dust

Equation E-11c is applicable when user-specified, variable household indoor dust lead concentrations are used in conjunction with either constant or variable, user-specified outdoor soil lead concentrations to determine INDUST[AGE] (see Equation E-9e).

soil_indoor[AGE] = dust_indoor[AGE] (E-11c)

where:
dust_indoor[AGE] = user-specified age-dependent indoor dust lead concentration

soil_indoor[AGE] = constant_dust_conc[AGE] (E-11d)

where:
constant_dust_conc[AGE] = default or user-specified constant value for indoor dust lead concentration

As indicated in Equation E-9.5, HouseFraction is determined by subtracting from 1, the total of the user-specified, constant fractions of dust ingested that come from the parent's occupation [OccupFraction], school [SchoolFraction], daycare [DaycareFraction], secondary homes [SecHomeFraction], and paint [OtherFraction]. The sum of all source fractions cannot exceed 1.0. As indicated in Equation E-9c, INDUSTA[AGE] is the sum of the lead intake rates from all five alternative sources. The individual lead intake rates for the alternative sources are defined in Equations E-12a through E-12e. In these equations, the lead intake rate is the product of the age-dependent, dust ingestion rate [DustTotal[AGE]], the user-specified, constant fraction of dust ingested that comes from that source (OccupFraction, SchoolFraction, DaycareFraction, SecHomeFraction, or OtherFraction), and the user-specified, constant dust lead concentration for dust from that source (OccupConc, SchoolConc, DaycareConc, SecHomeConc, or OtherConc).

HouseFraction = 1 – (OccupFraction – SchoolFraction – DaycareFraction – SecHomeFraction – OtherFraction) (E-9.5)

OCCUP[AGE] = DustTotal[AGE] * OccupFraction * OccupConc (E-12a)

SCHOOL[AGE] = DustTotal[AGE] * SchoolFraction * SchoolConc (E-12b)

DAYCARE[AGE] = DustTotal[AGE] * DaycareFraction * DaycareConc (E-12c)

SECHOME[AGE] = DustTotal[AGE] * SecHomeFraction * SecHomeConc (E-12d)

OTHER[AGE] = DustTotal[AGE] * OtherFraction *OtherConc (E-12e)

2.3.1.6 Exposure Component Parameters

For diet, water, and dust exposures, the user may choose from two or more methods of calculating exposure. Each of these exposure pathways has both concentration and intake parameter default values built into the IEUBK model that can be used to calculate default exposure levels. The following sections contain information on the default values for concentration and intake for air, diet, water, soil, and dust.

Parameter Values for Air

The default values for indoorpercent, air_concentration[AGE], time_out[AGE], and vent_rate[AGE] result in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	AGE INTERVAL (year)
IndoorConc[AGE]	0.03 µg/m^3	1–7
TWA[AGE]	0.033 µg/m^3	1
	0.036 µg/m^3	2
	0.039 µg/m^3	3
	0.042 µg/m^3	4
	0.042 µg/m^3	5
	0.042 µg/m^3	6
	0.042 µg/m^3	7
INAIR[AGE]	0.07 µg/day	1
	0.11 µg/day	2
	0.19 µg/day	3
	0.21 µg/day	4
	0.21 µg/day	5
	0.29 µg/day	6
	0.29 µg/day	7

Parameter Values for Diet

The default values for the lead intake rate from diet are shown in the following table:

PARAMETER	DEFAULT VALUE (µg/day)	AGE INTERVAL (year)
INDIET[AGE] (Direct specification)	2.26 1.96 2.13 2.04 1.95 2.05 2.22	1 2 3 4 5 6 7
INDIET[AGE][1] (Alternative diet specification)	2.26 1.96 2.13 2.04 1.95 2.05 2.22	1 2 3 4 5 6 7

[1]The model assumes no consumption of game animal meat, fish, home-grown vegetables or home-grown fruit unless specified by the user.

Parameter Values for Water

Using the default values for water_consumption[AGE] and constant_water_conc results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE (µg/day)	AGE INTERVAL (year)
INWATER[AGE] (Direct Specification)	0.80 2.00 2.08 2.12 2.20 2.32 2.36	1 2 3 4 5 6 7
INWATER[AGE] (Alternative Water Model)	0.77 1.92 2.00 2.04 2.12 2.23 2.27	1 2 3 4 5 6 7

Parameter Values for Soil

Using the default values for constant_soil_conc[AGE], soil_ingested[AGE], and weight_soil results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	AGE INTERVAL (year)
Soil-derived exterior dust ingestion rate	38.25 mg/day	1
	60.75 mg/day	2
	60.75 mg/day	3
	60.75 mg/day	4
	45.00 mg/day	5
	40.50 mg/day	6
	38.25 mg/day	7
INSOIL[AGE]	7.65 µg/day	1
	12.15 µg/day	2
	12.15 µg/day	3
	12.15 µg/day	4
	9.00 µg/day	5
	8.10 µg/day	6
	7.65 µg/day	7

Parameter Values for Dust

Using the default values for soil_ingested[AGE], percent_soil, and dust_indoor[AGE] results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	AGE INTERVAL (year)
DustTotal[AGE]	46.75 mg/day	1
	74.25 mg/day	2
	74.25 mg/day	3
	74.25 mg/day	4
	55.00 mg/day	5
	49.50 mg/day	6
	46.75 mg/day	7
INDUST[AGE]	9.35 µg/day	1
	14.85 µg/day	2
	14.85 µg/day	3
	14.85 µg/day	4
	11.00 µg/day	5
	9.90 µg/day	6
	9.35 µg/day	7
INDUSTA[AGE]	0 µg/day	1–7

Parameter Values for Alternative Dust

The default values for the alternative dust module are as shown in the following table:

PARAMETER	DEFAULT VALUE	AGE INTERVAL (year)
DustTotal[AGE]	46.75 mg/day	1
	74.25 mg/day	2
	74.25 mg/day	3
	74.25 mg/day	4
	55.00 mg/day	5
	49.50 mg/day	6
	46.75 mg/day	7
soil_indoor[AGE]	150 µg/g	1–7
INDUST[AGE]	8.42 µg/day	1
	13.37 µg/day	2
	13.37 µg/day	3
	13.37 µg/day	4
	9.90 µg/day	5
	8.91 µg/day	6
	8.42 µg/day	7
INDUSTA[AGE]	0 µg/day	1–7

2.3.2 Uptake Component

The uptake component models the manner in which lead intake (lead that has entered the child's body through ingestion or inhalation) is either transferred to the child's blood plasma or eliminated from the body. The equations that govern the uptake of lead into the blood plasma are discussed in this section. As noted in the previous section describing the exposure component of the IEUBKwin model, the notation [AGE] following a parameter name indicates that the parameter changes with the age of the child. The total of the lead uptake rates is the primary input to the biokinetic component of the model.

The fraction of lead intake that is actually absorbed into a child's system is known as the absorption fraction. The IEUBKwin model is structured so that the media-specific absorption fractions are constant at typical blood lead concentrations of concern. The media-specific absorption fractions include:

- ABSF for dietary lead absorption
- ABSD for dust lead absorption
- ABSS for soil lead absorption
- ABSW for drinking water lead absorption
- ABSO for paint chips lead absorption

In the absence of saturation effects, total lead absorption is equal to the sum of media-specific absorption values where absorption from each media is equal to the intake rate multiplied by the absorption fraction for that media. This quantity is denoted AVINTAKE, and is calculated using the Equation U-2:

$$\text{AVINTAKE} = (\text{ABSD} * \text{INDUST[AGE]}) + (\text{ABSD} * \text{INDUSTA[AGE]}) + (\text{ABSF} * \text{INDIET[AGE]}) + (\text{ABSF} * \text{INOTHER[AGE]}) + (\text{ABSS} * \text{INSOIL[AGE]}) + (\text{ABSW} * \text{INWATER[AGE]}) \quad \text{(U-2)}$$

To more accurately model lead uptake at higher intake rates, absorption fractions must be modified to separate non-saturable and saturable components. At doses where saturation of absorption is important, the actual uptake of lead will be less than AVINTAKE[AGE]. Lead uptake by the passive pathway is assumed to be linearly proportional to intake at all dose levels. The user parameter PAF is the fraction of the total net absorption at low intake rates that is attributable to non-saturable processes. Specifically, the lead uptake by the <u>passive</u> pathway is equal to:

$$\text{PAF} * \text{AVINTAKE[AGE]}$$

The IEUBKwin model assumes that the fraction of absorbed lead intake that is absorbed by non-saturable processes is the same for all media. At low doses, the quantity of lead absorbed by the <u>saturable</u> pathway is:

$$(1-\text{PAF}) * \text{AVINTAKE[AGE]}$$

However, at higher doses, only a certain fraction of this amount will be absorbed. The key parameter in this relationship is SATUPTAKE[AGE], which represents the level of available intake (AVINTAKE) at which the saturable pathway uptake reaches half of its maximum value. This half-saturation parameter depends on the age [AGE] of the child. The user can modify the value of SATUPTAKE[AGE] at age t = 24 months, denoted SATINTAKE2, through the GI/Bioavailability selection from the *Parameter Input* menu. From SATINTAKE2, the IEUBK model calculates SATUPTAKE[AGE] for all ages using Equation U-3. The parameter WTBODY(24) in the IEUBK model source code has a default value of 12.3.

$$\mathrm{SATUPTAKE}\left[\mathrm{MONTH}\right] = \mathrm{SATUPTAKE2} * \left[\frac{\mathrm{WTBODY}\left[\mathrm{MONTH}\right]}{\mathrm{WTBODY}\left[24\right]}\right] \qquad \text{(U-3)}$$

The fraction of potential saturable pathway uptake that is actually absorbed is given by:

$$\frac{1}{1+\left(\dfrac{AVINTAKE\left[AGE\right]}{SATUPTAKE\left[AGE\right]}\right)}$$

Thus, the amount of lead that is absorbed by saturable processes is calculated as:

$$\frac{\left(1-PAFS\right)*AVINTAKE\left[AGE\right]}{\left[1+\left(\dfrac{AVINTAKE\left[AGE\right]}{SATUPTAKE\left[AGE\right]}\right)\right]}$$

Total lead uptake from a medium is given by the sum of the active and passive components of uptake. Media-specific uptake rates are calculated using the same proportions as total intake. For example, the non-saturable uptake component for soil is given by:

*INSOIL[AGE] * ABSS * AVS * PAFS*

where,
PAFS = PAF for soil (see below)

Whereas the saturable uptake component for soil is:

$$\frac{\left(1-PAFS\right)*INSOIL\left[AGE\right]*ABSS*AVS}{1+\left(\dfrac{AVINTAKE\left[AGE\right]}{SATUPTAKE\left[AGE\right]}\right)}$$

Uptake rates for other media are calculated in the same way.

The absorption coefficients for each medium (diet, water, dust, paint, soil, and alternate dust) are listed in Appendix A as Equations U-1a through U-1f. The saturable uptake component for each medium is assigned a unique variable name in the source code: PAFD for diet, PAFW for water, PAFD for dust and alternate dust, PAFS for soil, and PAFP for paint. The saturable uptake component for each medium is set to a constant value except for air. The absorption coefficient for air (air_absorp[AGE]) varies with age; it is listed in Appendix A as Equation U-4. With the absorption coefficient for each medium, the total monthly lead uptake can be calculated using Equation U-5.

UPTAKE[MONTH] = 30*(UPDIET[MONTH] + UPWATER[MONTH] + UPDUST[MONTH] +
UPSOIL[MONTH] + UPDUSTA[MONTH] + UPOTHER[MONTH] + UPAIR[MONTH])
(U-5)

where:
30 = conversion factor from daily media-specific uptakes to monthly total uptake

2.3.3 Biokinetic Component

Based on the total lead uptake rate (UPTAKE[MONTH]), the biokinetic component of the IEUBKwin model calculates age-dependent lead masses in each of the body compartments (plasma-extra-cellular fluid (ECF), liver, kidney, trabecular bone, cortical bone, and other soft tissue). The concentration of lead in blood is then calculated by dividing mass of lead in the blood plasma and red blood cells by the volume of blood.

The calculations in the biokinetic module occur sequentially, beginning with a determination of the volumes and weights of specific compartments in a child's body, as a function of age. Next, the transfer times of lead between the compartments and through elimination pathways are estimated. Initial compartmental lead masses and an initial blood lead concentration are calculated for a newborn child. Then successive values are calculated for the compartmental lead masses and blood lead concentration of a child at each iteration time. These calculations are performed for a child from birth to age 84 months.

The equations for compartmental lead transfer times are listed in Appendix A as Equations B-1a through B-1h, B-2a through B-2o, and B-2.5. Equation B-2.5, as written in IEUBKwin model source code, indicates an age-dependent array for MRBC[STEPS]. The source code was taken directly from the IEUBK model (version 0.99d); thus, IEUBKwin model results are the same as those computed from the equation as written in the IEUBK model (version 0.99d) source code.

The parameter WTBODY(24) in Equations B-1a through B-1e has a default value of 12.3 in the model source code. For simplification purposes, storage arrays (ResCoef and ALLOMET) are used in the IEUBK model source code to store parameter and constant values in Equations B-1a through B-1g, B-2a, and B-3. The exponent, 0.333, in Equations B-1a through B-1e is stored in the ALLOMET array. Parameters such as TBLUR(24), TBLLIV(24), TBLOTH(24), TBLKID(24), TBLBONE(24), RATFECUR, and RATOUTFEC in Equations B-1a through B-1g and constants in Equations B-2a and B-3 are stored in the ResCoef array in the IEUBK model source code. The equations for blood to plasma_ECF lead mass ratio, fluid volumes and organ weights, difference equations, tissue lead masses and blood lead concentration at birth, compartmental lead masses, and blood lead concentration are B-3, B-4a through B-4d, B-5a through B-5m, B-6.5a through B-6.5i, B-7a through B-7i, B-8a through B-9i, and B-10a through B-10c, respectively (see Appendix A).

In the IEUBKwin model source code, the parameters in Equations B-8a through B-10a are set up as vectors that store 84 monthly values. The source code computes two values for each parameter, one for the current time step and one for the previous time step. These parameters are updated at the end of each time step. The difference in the implementation of these parameters in the IEUBKwin model source code does not affect the results of the model.

2.3.4 Probability Distribution Component

The fourth component of the IEUBKwin model estimates, for a hypothetical child or population of children, a plausible distribution of blood lead concentrations centered on the geometric mean blood lead concentration predicted by the model from available information about children's exposure to lead. From this distribution, the IEUBKwin model calculates the probability that children's blood lead concentrations will exceed the user-selected level of concern.

Risk estimation and plotting of probability distributions requires the selection of two parameters, the blood lead level of concern (cutoff level) and the Geometric Standard Deviation (GSD). A value of 10 µg/dL is generally used as the blood lead level of concern and 1.6 for the GSD, but other values can be selected by the user.

The user should note that results obtained from this version of IEUBKwin may differ slightly from results obtained from the 0.99d version and earlier versions of IEUBKwin (versions 244 and earlier). In this version of IEUBKwin (and all versions since version 1.0 (build 245), the algorithms have been revised so that the same algorithm is used in the batch and single modes. The current version of the model uses the polynomial function. This approach is more accurate (error $<10^{-8}$), more stable (i.e., it is not affected by the integration interval), and is more computationally efficient (i.e., iterative calculations are not needed to achieve a low error rate).

$$P(x) = 1 - Z(x)\left(b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4 + b_5 t^5\right) + \in(x)$$

$$x = \frac{\ln(PbBcutoff) - \ln(GM)}{\ln(GSD)}$$

$$t = \frac{1}{1 + (p \cdot |x|)}$$

$$Z = \frac{1}{\sqrt{2\pi}} \cdot e^{-\left(x^2/2\right)}$$

If x < 0 then P(cutoff) = 1 – P(x)

If x > 0 then P(cutoff) = P(x)

where:

(x) < 7.510^{-8} (error)

p	=	0.2316419
b_1	=	0.319381530
b_2	=	-0.356563782
b_3	=	1.781477937
b_4	=	-1.82125578
b_5	=	1.330274429

3.0 Software Detail Design

The detailed design of the IEUBKwin model is presented in this section. For each component and its associated modules, the inputs, processing in terms of calculations, and outputs are presented in table form.

3.1 OVERALL DESIGN DESCRIPTION

To design the IEUBKwin model, a series of menus was created from which the user can select screens for input of specific values appropriate to the situation that is being modeled. In general, the inputs, processing, and outputs are similar for all the model components—Exposure, Uptake, Biokinetic, and Probability Distribution. The inputs are values entered by the user or passed from the previous component. The processing performed is the solving of the algorithm for the particular component using the calculations identified in the requirements section (as determined by scientific research). The output is the values passed to the following component, used as input to the graphing routine, or the graph itself.

3.1.1 Local Data

The model uses local data only when the user calls up saved data as input to a graph. In addition, some of the components contain values that are coded internally, and which are accessed during the processing of algorithms.

3.1.2 Control

As a standalone system, internal control of the program is not a major issue. The system is dependent on the user entering adequate, valid, and complete data; once the model runs are initiated, the model runs as designed and tested.

3.1.3 Error Handling

The errors encountered by the IEUBKwin model are those relating to data input. When the user enters data that is invalid in terms of range or format, the system displays error messages which prompt the user to enter valid data. These are included in the IEUBKwin model's source code for every data input window for each model component.

In addition, the IEUBKwin model displays a warning message in the model output when the predicted blood lead concentration exceeds 30 µg/dL, the calibrated and empirical validation limit for predicted blood lead (Zaragoza, L. and Hogan, K., 1998. The Integrated Exposure Uptake Biokinetic Model for Lead in Children: Independent Validation and Verification.

Environmental Health Perspectives 106 (supplement 6): 1555). However, empirical validation of the model did not address situations where the predicted blood lead concentration exceeds 30 µg/dL; therefore, such results must be interpreted with caution.

3.1.4 Data Conversion

In the IEUBKwin model, all parameters are allowed to be entered to six digits. All output values of the float type are controlled at 3 significant digits after the decimal except for blood lead concentration which is controlled to one significant figure after decimal point.

3.1.5 Test Structure

The testing structure for the IEUBKwin model is described in section 4.0.

3.1.6 Manual Procedures

The IEUBKwin model has a significant number of manual procedures simply because it is designed as a Windows system. The manual procedures include using the computer’s mouse to select menus and to make selections from those menus. Once the selection has been made, the user must use the mouse and keyboard to input the required data. For saving results to a file, or identifying a previous results file as input to a graph, the user is prompted to enter the appropriate filenames.

Output data from the batch mode runs are ASCII files that can be loaded into almost any statistical analysis package or spreadsheet program that the user may want to use. The IEUBKwin batch mode output files will require little or no editing before being imported into other programs, unless the missing value code (---) is incompatible with the user's package. It is recommended that the user apply a variety of graphical and statistical techniques in evaluating the output of batch mode model runs.

3.2 EXPOSURE COMPONENT

The various media exposure modules are presented in the following subsections. For each exposure module, the inputs are listed along with descriptions of the sequential functions that occur in processing.

3.2.1 Air Lead Exposure Module

Inputs (from the Air Data Window): air_absorp[0], air_absorp[1], air_absorp[2], air_absorp[3], air_absorp[4], air_absorp[5], air_absorp[6], time_out[0], time_out[1], time_out[2], time_out[3], time_out[4], time_out[5], time_out[6], vent_rate[0], vent_rate[1], vent_rate[2], vent_rate[3], vent_rate[4], vent_rate[5], vent_rate[6], air_concentration[0], air_concentration[1], air_concentration[2], air_concentration[3], air_concentration[4], air_concentration[5], air_concentration[6], indoorpercent

ClassName.Function	Description
CAir.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CAir.UpdateData()	Updates and stores data temporarily in a file called “Air.tmp.” UpdateData() takes the user input data to the application.
CAir.Air_TakeData()	Opens and reads data from “Air.tmp” or “Air.inp.” The file “Air.inp” stores default values for each of the variables listed under Inputs. Numeric values for air_absorp[0], air_absorp[1], air_absorp[2], air_absorp[3], air_absorp[4], air_absorp[5], air_absorp[6], time_out[0], time_out[1], time_out[2], time_out[3], time_out[4], time_out[5], time_out[6], vent_rate[0], vent_rate[1], vent_rate[2], vent_rate[3], vent_rate[4], vent_rate[5], vent_rate[6], air_concentration[0], air_concentration[1], air_concentration[2], air_concentration[3], air_concentration[4], air_concentration[5], and air_concentration[6] are stored in the following arrays: air_absorp[AGE], time_out[AGE], vent_rate[AGE], and air_concentration[AGE].
CAir.Calc_INAIR()	Calculates INAIR[AGE] using Equations E-1 through E-3.
CAir.Write_Data_File()	Writes input data to a temporary file.

3.2.2 Dietary Lead Exposure Module

Inputs (from the Dietary Data Window): diet_intake[0], diet_intake[1], diet_intake[2], diet_intake[3], diet_intake[4], diet_intake[5], diet_intake[6], YesNo_AlternativeDiet, UserFishConc, userFishFracPercent, UserFruitConc, userFruitFracPercent, UserGameConc, userGameFracPercent, UserVegConc, userVegFracPercent, userFishFraction, userVegFraction, userFruitFraction, userGameFraction

Class Name.Function	Description
CDiet.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CDiet.UpdateData()	Updates and stores data temporarily in a file called "Diet.tmp." UpdateData() takes the user input data to the application. Percent values for userFruitFracPercent, userGameFracPercent, userFishFracPercent, and userVegFracPercent are converted to their decimal fraction equivalent.
CDiet.Diet_TakeData()	Opens and reads data from "Diet.tmp" or "Diet.inp." The file "Diet.inp" stores default values for each of the variables listed under Inputs. Numeric values for m_diet_intake[0], diet_intake[1], diet_intake[2], diet_intake[3], diet_intake[4], diet_intake[5], and diet_intake[6] are stored in the array diet_intake[AGE].
CDiet.Calc_INDIET()	Calculates INDIET[AGE] whose value depends on the value of YesNo_AlternativeDiet. If YesNo_AlternativeDiet=0, INDIET[AGE] is calculated using Equation E-4a; otherwise, INDIET[AGE] is calculated using Equations E-4b and E-5d through E-5l.
CDiet.Write_Data_File()	Writes input data to a temporary file.

3.2.3 Water Lead Exposure Module

Inputs (from the Water Data Window): constant_water_conc, water_consumption[0], water_consumption[1], water_consumption[2], water_consumption[3], water_consumption[4], water_consumption[5], water_consumption[6], FirstDrawConc, HomeFlushedConc, FountainConc, FirstDrawPercent, FountainPercent, FountainFraction, FirstDrawFraction, YesNo_AlternativeWater.

Class Name.Function	Description
CWater.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CWater.UpdateData()	Updates and stores data temporarily in a file called "Water.tmp." UpdateData() takes the user input data to the application. Percent values for FirstDrawPercent and FountainPercent are converted to their decimal fraction equivalent.
CWater.Water_TakeData()	Opens and reads data from "Water.tmp" or "Water.inp." The file "Water.inp" stores default values for each of the variables listed under Inputs. Numeric values for water_consumption[0], water_consumption[1], water_consumption[2], water_consumption[3], water_consumption[4], water_consumption[5], and water_consumption[6] are stored in the array water_consumption[AGE].
CWater.Calc_INWATER()	Calculates INWATER[AGE] whose value depends on the value of YesNo_AlternativeWater. If YesNo_AlternativeWate r= 0, INWATER[AGE] is calculated using Equation E-6a; otherwise, INWATER[AGE] is calculated using Equations E-6b and E-7.
CWater.Write_Data_File()	Writes input data to a temporary file.

3.2.4 Soil/Dust Lead Exposure Module

Inputs (from the Soil/Dust Window): weight_soil, soil_indoor[0], soil_indoor[1], soil_indoor[2], soil_indoor[3], soil_indoor[4], soil_indoor[5], soil_indoor[6], soil_content[0], soil_content[1], soil_content[2], soil_content[3], soil_content[4], soil_content[5], soil_content[6], soil_ingested[0], soil_ingested[1], soil_ingested[2], soil_ingested[3], soil_ingested[4], soil_ingested[5], soil_ingested[6], contrib_percent, multiply_factor, OtherConc, OtherFraction, SchoolConc, SchoolFraction, SecHomeConc, SecHomeFraction, DaycareConc, DaycareFraction, OccupConc, OccupFraction, AvgMultiSrc, HouseFraction, constant_soil_conc[0], constant_soil_conc[1], constant_soil_conc[2], constant_soil_conc[3], constant_soil_conc[4], constant_soil_conc[5], constant_soil_conc[5], constant_dust_conc[0], constant_dust_conc[1], constant_dust_conc[2], constant_dust_conc[3], constant_dust_conc[4], constant_dust_conc[5], constant_dust_conc[6], air_concentration[0], air_concentration[1], air_concentration[2], air_concentration[3], air_concentration[4], air_concentration[5], air_concentration[6], const_outdoor_soil, const_indoor_dust, dust_indoor[0], dust_indoor[1], dust_indoor[2], dust_indoor[3], dust_indoor[4], dust_indoor[5], dust_indoor[6], vary_indoor, vary_outdoor

Class Name.Function	Description
CSoil.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CSoil.UpdateData()	Updates and stores data temporarily in a file called “Soil.tmp.” UpdateData() takes the user input data to the application. Percent values for DaycareFracPercent, OccupFracPercent, OtherFracPercent, SchoolFracPercent, SecHomeFracPercent, and HouseFracPercent are converted to their decimal fraction equivalent.
CSoil.Soil_TakeData()	Opens and reads data from “Soil.tmp” or “Soil.inp.” The file “Soil.inp” stores default values for each of the variables listed under Inputs. Numeric values for soil_indoor[0], soil_indoor[1], soil_indoor[2], soil_indoor[3], soil_indoor[4], soil_indoor[5], soil_indoor[6], soil_content[0], soil_content[1], soil_content[2], soil_content[3], soil_content[4], soil_content[5], soil_content[6], soil_ingested[0], soil_ingested[1], soil_ingested[2], soil_ingested[2], soil_ingested[3], soil_ingested[4], soil_ingested[5], and soil_ingested[6] are stored in the following arrays: soil_indoor[AGE], soil_content[AGE], and soil_ingested[AGE].
CSoil.Calc_INSOIL()	Calculates INSOIL[AGE], INDUST[AGE], and INDUSTA[AGE] whose values depend on the values of m_altsrc, vary_indoor, vary_outdoor.
CSoil.Write_Data_File()	Writes input data to a temporary file.
CSoil.GetExtraData()	Takes data from the air module and MSA.
CSoil.MSA_TakeData()	Takes data from the MSA.

3.2.5 Maternal Lead Exposure Module

Inputs (from the Maternal Data Window): PBBLDMAT

Class Name.Function	Description
CMaternal.Check_Data_Valid()	Checks whether input-data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CMaternal.UpdateData()	Updates and stores data temporarily in a file called “Maternal.tmp.” UpdateData() takes the user input data to the application.
CMaternal.Maternal_TakeData()	Opens and reads data from “Maternal.tmp” or “Maternal.inp.” The file “Maternal.inp” stores default values for each of the variables listed under Inputs.
CMaternal.Write_Data_File()	Writes input data to a temporary file.

3.2.6 Other Lead Exposure Module

Inputs (from the Alternate Source Data Window): other_intake[0], other_intake[1], other_intake[2], other_intake[3], other_intake[4], other_intake[5], other_intake[6].

Class Name.Function	Description
COther.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
COther.UpdateData()	Updates and stores data temporarily in a file called “Other.tmp.” UpdateData() takes the user input data to the application.
COther.Other_TakeData()	Opens and reads data from “Other.tmp” or “Other.inp.” The file “Other.inp” stores default values for each of the variables listed under Inputs. Numeric values for other_intake[0], other_intake[1], other_intake[2], other_intake[3], other_intake[4], other_intake[5], and other_intake[6] are stored in the array other_intake[AGE].
COther.Write_Data_File()	Writes input data to a temporary file.

3.2.7 GI/Bioavailability Module

Inputs (from the Alternate Source Data Window): ABSD Percent, ABSF Percent, ABSO Percent, ABSS Percent, ABSW Percent, PAFs, SATINTAKE2.

Class Name.Function	Description
CGiBio.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CGiBio.UpdateData()	Updates and stores data temporarily in a file called "GiBio.tmp." UpdateData() takes the user input data to the application.
CGiBio.Other_TakeData()	Opens and reads data from "GiBio.tmp" or "GiBio.inp." The file "GiBio.inp" stores default values for each of the variables listed under Inputs.
CGiBio.Write_Data_File()	Writes input data to a temporary file.

3.3 UPTAKE COMPONENT

The inputs to the Uptake component are listed below along with a description of the function that occurs in the model processing.

Inputs: These variables were derived from the Exposure Component of the model: INAIR[AGE], INSOIL[AGE], INDUST[AGE], INDUSTA[AGE], INWATER[AGE], INDIET[AGE], INOTHER[AGE], PBBLDMAT

ClassName.Function	Description
BaseComp.Calc_UPTAKE()	Calculates the values for UPAIR[MONTH], UPDIET[MONTH], UPDUST[MONTH], UPDUSTA[MONTH], UPSOIL[MONTH], UPWATER[MONTH], UPOTHER[MONTH], and UPTAKE[MONTH] using Equations U-1a through U-1f, U-2, U-3, U-4, and U-5.

3.4 BIOKINETIC COMPONENT

The inputs to the Biokinetic component are listed below along with a description of the function that occurs in the model processing.

Inputs: This variable was derived from the Uptake Component of the model: UPTAKE[MONTH]

Class Name.Function	Description
BaseComp.Calc_Biokinetic()	Calculates the lead masses in each body compartments (MPLECF[2], MPLASM[2], MRBC[2], MLIVER[2], MKIDNEY[2], MOTHER[2], MTRAB[2], and MCORT[2]) using the difference equations B-6.5a through B-6.5i and intermediate equations B-1a through B-1h, B-2a through B-2o, B-2.5, B-3, B-4a through B-4d, B-5a through B-5m, B-6.5a through B-6.5i, B-7a through B-7i, B-8a through B-8d, B-9a through B-9i, and B-10a through B-10c.

4.0 Documentation for the IEUBKwin

Several documents are required as documentation for the IEUBKwin model. The *System Requirements and Design* is designed for use by programmers. By contrast, The *User's Guide* will be widely used by end users of the IEUBKwin model.

The system documentation for the IEUBKwin model includes the following:

- System Requirements and Design Specifications
- Complete printout of the IEUBK model source code
- Data Crosswalk

These documents were prepared according to the *OSWER System Life Cycle Management Guidance* (April 1988) and CMMI (Level 3). The audience for these documents will be programmers. The purpose of these documents was to demonstrate that the recoding of the IEUBK model was performed correctly and to document the recoding effort to satisfy challenges, questions, and concerns from Congress as well as PRP litigation. The system documentation will also be an important reference for the future in the event that enhancements to the IEUBKwin model are necessary. Changes to the IEUBKwin model may occur because of changes in the scientific understanding that affect equations or defaults in the current model source code (*e.g.*, the changes to variable values that prompted the development of IEUBKwin version 1.1). The detailed design documentation will assist future designers and programmers with system maintenance by clearly defining the current system requirements and technical design.

APPENDIX A

EQUATIONS AND PARAMETERS IN THE IEUBKwin MODEL

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The parameters and equations presented here are not a line by line documentation of the IEUBKwin model source code. Although most of the symbols and notations are identical to the model source code, some notations may differ but are mathematically equivalent. The equations and parameters presented in this document have been simplified for clarity. All the equations, with the exception of those listed below, were taken from the *Technical Support Document (TSD)*: *Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children* (v 0.99d) [December 1994]. The TSD (December 1994) is an update of the TSD (July 1994) and was prepared and reviewed by the Technical Review Workgroup for Metals and Asbestos (TRW).

Appendix A consists of three tables which contain the equations used in the IEUBKwin model. Exposure equations are listed in Table A-1. Tables A-2 and A-3 contain the equations for the uptake and biokinetic components, respectively. Within each table, similar equations or equations which combine to achieve a common purpose are grouped together. For example, in Table A-1, the equation groups are defined by the different environmental media.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT

GROUP	NUMBER	EQUATION
Air Lead	E-1	IndoorConc[AGE] = 0.01 * indoorpercent * air_concentration[AGE]
	E-2	$\text{TWA[AGE]} = \dfrac{\left[\text{time\_out}\left[\text{AGE}\right] * \text{air\_concentration}\left[\text{AGE}\right]\right] + \left[\left(24 - \text{time\_out[AGE]}\right) * \text{IndoorConc}\left[\text{AGE}\right]\right]}{24}$
	E-3	INAIR[AGE] = TWA[AGE] * vent_rate[AGE]
Dietary Lead	E-4a *or* E-4b	INDIET[AGE] = diet_intake[AGE] *or* INDIET[AGE] = DietTotal[AGE] = InOtherDiet[AGE]+ InMeat[AGE] + InGame[AGE] + InFish[AGE] + InCanVeg[AGE] + InFrVeg[AGE] + InHomeVeg[AGE] + InCanFruit[AGE] + InFrFruit[AGE] + InHomeFruit[AGE]
	E-4c	InOtherDiet[AGE] = InDairy[AGE] + InJuice[AGE] + InNuts[AGE] + InBread[AGE] + InPasta[AGE] + InBeverage[AGE] + InCandy[AGE] + InSauce[AGE] + InFormula[AGE] + InInfant[AGE]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT

GROUP	NUMBER	EQUATION
Dietary Lead (continued)	E-4d	beverage[AGE] = beverageConc * beverage_Consump[AGE]
	E-4e	bread[AGE] = breadConc * bread_Consump[AGE]
	E-4f	can_fruit[AGE] = canFruitConc * canFruit_Consump[AGE]
	E-4g	can_veg[AGE] = canVegConc * CanVeg_Consump[AGE]
	E-4h	candy[AGE] = candyConc * candy_Consump[AGE]
	E-4i	dairy[AGE] = dairyConc * dairy_Consump[AGE]
	E-4j	f_fruit[AGE] = fFruitConc * fFruit_Consump[AGE]
	E-4k	f_veg[AGE] = fVegConc * fVeg_Consump[AGE]
	E-4l	formula[AGE] = formulaConc * formula_Consump[AGE]
	E-4m	infant[AGE] = infantConc * infant_Consump[AGE]
	E-4n	juices[AGE] = juiceConc * juice_Consump[AGE]
	E-4o	meat[AGE] = meatConc * meat_consump[AGE] or meat_Consump[AGE]
	E-4p	nuts[AGE] = nutsConc * nuts_Consump[AGE]
	E-4q	pasta[AGE] = pastaConc * pasta_Consump[AGE]
	E-4r	sauce[AGE] = sauceConc * sauce_Consump[AGE]
	E-5a	meatFraction = 1 – userFishFraction – userGameFraction
	E-5b	vegFraction = 1 – userVegFraction
	E-5c	fruitFraction = 1 – userFruitFraction

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT

GROUP	NUMBER	EQUATION
Dietary Lead (continued)	E-5d	InMeat[AGE] = meatFraction * meat[AGE]
	E-5e	InCanVeg[AGE] = vegFraction/2 * can_veg[AGE]
	E-5f	InFrVeg[AGE] = vegFraction/2 * f_veg[AGE]
	E-5g	InCanFruit[AGE] = fruitFraction/2 * can_fruit[AGE]
	E-5h	InFrFruit[AGE] = fruitFraction/2 * f_fruit[AGE]
	E-5i	InHomeFruit[AGE] = userFruitFraction * (canFruit_Consump[AGE] + fFruit_Consump [AGE]) * UserFruitConc
	E-5j	InHomeVeg[AGE] = userVegFraction * (canVeg_Consump[AGE] + fVeg_Consump[AGE]) * UserVegConc
	E-5k	InFish[AGE] = userFishFraction * meat_consump[AGE] * UserFishConc
	E-5l	InGame[AGE] = userGameFraction * meat_consump[AGE] * UserGameConc
	E-5m	InDairy[AGE] = Dairy[AGE]
	E-5n	InJuice[AGE] = Juices[AGE]
	E-5o	InNuts[AGE] = Nuts[AGE]
	E-5p	InBread[AGE] = Bread[AGE]
	E-5q	InPasta[AGE] = Pasta[AGE]
	E-5r	InBeverage[AGE] = Beverage[AGE]
	E-5s	InCandy[AGE] = Candy[AGE]
	E-5t	InSauce[AGE] = Sauce[AGE]
	E-5u	InFormula[AGE] = Formula[AGE]
	E-5v	InInfant[AGE] = Infant[AGE]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT

GROUP	NUMBER	EQUATION
Water Lead	E-6a *or* E-6b	INWATER[AGE] = water_consumption[AGE] * constant_water_conc *or*
		INWATER[AGE] = water_consumption[AGE] * (HomeFlushedConc * HomeFlushedFraction + FirstDrawConc * FirstDrawFraction + FountainConc * FountainFraction)
	E-7	*HomeFlushedFraction = 1 - FirstDrawFraction - FountainFraction*
Soil Lead	E-8a *or* E-8b	INSOIL[AGE] = constant_soil_conc[AGE] * soil_ingested[AGE] * (0.01 * weight_soil) *or* INSOIL[AGE] =soil_content[AGE]* soil_ingested[AGE] * (0.01 * weight_soil)
Dust Lead	E-9a	INDUST[AGE] = constant_dust_conc[AGE] * soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-9b	INDUST[AGE] = DustTotal[AGE] * soil_indoor[AGE] * HouseFraction
	E-9c	INDUSTA[AGE] = OCCUP[AGE] + SCHOOL[AGE] + DAYCARE[AGE] + SECHOME[AGE] + OTHER[AGE]
	E-9d	INDUST[AGE] = soil_indoor[AGE] * soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-9e	INDUST[AGE] = dust_indoor[AGE] * soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-9.5	*HouseFraction = 1 – (OccupFraction - SchoolFraction - DaycareFraction - SecHomeFraction – OtherFraction)*
	E-10	DustTotal[AGE] = soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-11a	soil_indoor[AGE] = (contrib_percent *soil_content[AGE]) + (multiply_factor * air_concentration[AGE])
	E-11b	soil_indoor[AGE] = (contrib_percent * constant_soil_conc[AGE]) + (multiply_factor * air_concentration[AGE])
	E-11c	soil_indoor[AGE] = dust_indoor[AGE]
	E-11d	soil_indoor[AGE] = constant_dust_conc[AGE]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT

GROUP	NUMBER	EQUATION
Dust Lead	E-12a	OCCUP[AGE] = DustTotal[AGE] * OccupFraction * OccupConc
	E-12b	SCHOOL[AGE] = DustTotal[AGE] * SchoolFraction * SchoolConc
	E-12c	DAYCARE[AGE] = DustTotal[AGE] * DaycareFraction * DaycareConc
	E-12d	SECHOME[AGE] = DustTotal[AGE] * SecHomeFraction * SecHomeConc
	E-12e	OTHER[AGE] = DustTotal[AGE] * OtherFraction *OtherConc

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Absorption Coefficients, Passive Uptakes		
		Note: In calculating uptake, first, medium-specific passive uptakes are calculated using equations U1a-U1f, then, the medium-specific passive uptake values are updated with the inclusion of the active uptake contribution using equations U1g-U1l.
Dust Lead (continued)	U-1a	UPDIET[MONTH]=PAFF*ABSF*AVF*INDIET[AGE]
	U-1b	UPWATER[MONTH]=PAFW*ABSW*AVW*INWATER[AGE]
	U-1c	UPDUST[MONTH]=PAFD*ABSD*AVD*INDUST[AGE]
	U-1d	UPDUSTA[MONTH]=PAFD*ABSD*AVD*INDUSTA[AGE]
	U-1e	UPSOIL[MONTH]=PAFS*ABSS*AVS*INSOIL[AGE]
Absorption Coefficients, Active Uptakes		
Dust Lead (continued)	U-1g	$\mathrm{UPDIET}[\mathrm{MONTH}] = \mathrm{UPDIET}[\mathrm{MONTH}] + \left[\dfrac{(1-\mathrm{PAFF}) * \mathrm{ABSF} * \mathrm{AVF} * \mathrm{INDIET}[\mathrm{AGE}]}{1+\dfrac{\mathrm{AVINTAKE}[\mathrm{MONTH}]}{\mathrm{SATUPTAKE}[\mathrm{MONTH}]}}\right]$
	U-1h	$\mathrm{UPWATER}[\mathrm{MONTH}] = \mathrm{UPWATER}[\mathrm{MONTH}] + \left[\dfrac{(1-\mathrm{PAFW}) * \mathrm{ABSW} * \mathrm{AVW} * \mathrm{INWATER}[\mathrm{AGE}]}{1+\dfrac{\mathrm{AVINTAKE}[\mathrm{MONTH}]}{\mathrm{SATUPTAKE}[\mathrm{MONTH}]}}\right]$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
	U-1i	$$UPDUST[MONTH] = UPDUST[MONTH] + \left[\frac{(1-PAFD) * ABSD * AVD * INDUST[AGE]}{1+\frac{AVINTAKE[MONTH]}{SATUPTAKE[MONTH]}}\right]$$
	U-1j	$$UPDUSTA[MONTH] = UPDUSTA[MONTH] + \left[\frac{(1-PAFD) * ABSD * AVD * INDUSTA[AGE]}{1+\frac{AVINTAKE[MONTH]}{SATUPTAKE[MONTH]}}\right]$$
	U-1k	$$UPSOIL[MONTH] = UPSOIL[MONTH] + \left[\frac{(1-PAFS) * ABSS * AVS * INSOIL[AGE]}{1+\frac{AVINTAKE[MONTH]}{SATUPTAKE[MONTH]}}\right]$$
	U-2	AVINTAKE = ABSD * INDUST[AGE] + ABSD * INDUSTA[AGE] + ABSS * INSOIL[AGE] + ABSF * INDIET[AGE] + ABSO * INOTHER[AGE] + ABSW * INWATER[AGE]
	U-3	$$SATUPTAKE[MONTH] = SATUPTAKE2 * \left[\frac{WTBODY[MONTH]}{WTBODY[24]}\right]$$
Total Lead Uptake	U-4	UPAIR[MONTH] = air_absorp[AGE] * 0.01 * INAIR[AGE]
	U-5	
UPTAKE[MONTH] = 30 * {(UPDIET[MONTH] + UPWATER[MONTH] + UPDUST[MONTH] + UPSOIL[MONTH] + UPDUSTA[MONTH] + UPOTHER[MONTH] + UPAIR[MONTH]}		

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times		
	B-1a	$$TBLUR\left[MONTH\right] = TBLUR\left[24\right] * \left(\frac{WTBODY\left[MONTH\right]}{WTBODY\left[24\right]}\right)^{0.333}$$
	B-1b	$$TBLLIV\left[MONTH\right] = TBLLIV\left[24\right] * \left(\frac{WTBODY\left[MONTH\right]}{WTBODY\left[24\right]}\right)^{0.333}$$
	B-1c	$$TBLOTH\left[MONTH\right] = TBLOTH\left[24\right] * \left(\frac{WTBODY\left[MONTH\right]}{WTBODY\left[24\right]}\right)^{0.333}$$
	B-1d	$$TBLKID\left[MONTH\right] = TBLKID\left[24\right] * \left(\frac{WTBODY\left[MONTH\right]}{WTBODY\left[24\right]}\right)^{0.333}$$
	B-1e	$$TBLBONE\left[MONTH\right] = TBLBONE\left[24\right] * \left(\frac{WTBODY\left[MONTH\right]}{WTBODY\left[24\right]}\right)^{0.333}$$
	B-1f	TBLFEC[MONTH] = RATFECUR * TBLUR[MONTH]
	B-1g	TBLOUT[MONTH] = RATOUTFEC * TBLFEC[MONTH]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times (*continued)*	B-1h	$TBONEBL[MONTH] = CRBONEBL[MONTH] * TBLBONE[MONTH] * \left[\frac{\{WTTRAB[MONTH] + WTCORT[MONTH]\}}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)} \right]$
	B-2a	TPLRBC = 0.1
	B-2b	$TRBCPL = TPLRBC * \left[RATBLPL - \frac{0.55}{(0.55 + 0.73)} \right]$
	B-2c	$TPLUR[MONTH] = \frac{TBLUR[MONTH]}{RATBLPL}$
	B-2d	$TPLLIV[MONTH] = \frac{TBLLIV[MONTH]}{RATBLPL}$
	B-2e	$TLIVPL[MONTH] = CRLIVBL[MONTH] * \left[\frac{TBLLIV[MONTH]}{1 - \frac{TBLLIV[MONTH]}{TBLFEC[MONTH]}} \right] * \left[\frac{WTLIVER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)} \right]$
	B-2f	$TLIVFEC[MONTH] = CRLIVBL[MONTH] * TBLFEC[MONTH] * \left[\frac{WTLIVER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)} \right]$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times (*continued*)	B-2g	$TPLKID[MONTH] = \frac{TBLKID[MONTH]}{RATBLPL}$
	B-2h	$TKIDPL[MONTH] = CRKIDBL[MONTH] * TBLKID[MONTH] * \left[\frac{WTKIDNEY[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2i	$TPLTRAB[MONTH] = \frac{TBLBONE[MONTH]}{(0.2 * RATBLPL)}$
	B-2j	TTRABPL[MONTH] = TBONEBL[MONTH]
	B-2k	$TPLCORT[MONTH] = \frac{TBLBONE[MONTH]}{(0.8 * RATBLPL)}$
	B-2l	TCORTPL[MONTH] = TBONEBL[MONTH]
	B-2m	$TPLOTH[MONTH] = \frac{TBLOTH[MONTH]}{RATBLPL}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times (*continued*)	B-2n	$TOTHPL[MONTH] = CROTHBL[MONTH] * \left[\frac{TBLOTH[MONTH]}{\left(1 - \frac{TBLOTH[MONTH]}{TBLOUT[MONTH]}\right)} \right] * \left[\frac{WTOTHER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)} \right]$
	B-2o	$TOTHOUT[MONTH] = CROTHBL[MONTH] * TBLOUT[MONTH] - \left[\frac{WTOTHER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)} \right]$
	B-2.5	$TPLRBC2[STEPS] = \frac{TPLRBC}{\left[1 - \frac{MRBC[STEPS]}{(VOLRBC([MONTH]-1)/CONRBC)}\right]}$
Blood to Plasma-ECF Lead Mass Ratio	B-3	RATBLPL = 100
Fluid Volumes and Organ Weights	B-4a	CRKIDBL[MONTH] = 0.777 + [2.35 * {1 - exp(-0.0468*[MONTH])}]
	B-4b	CRLIVBL[MONTH] = 1.1 + [3.5 * {1 - exp(-0.0462*[MONTH])}]
	B-4c	CRBONEBL[MONTH] = 6.0 + [215.0 * {1 - exp(-0.000942*[MONTH])}]
	B-4d	CROTHBL[MONTH] = 0.931 + [0.437 * {1 - exp(-0.00749*[MONTH])}]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT

GROUP	NUMBER	EQUATION
Fluid Volumes and Organ Weights (*continued*)	B-5a	$\text{VOLBLOOD}[\text{MONTH}] = \left[\dfrac{10.67}{1+\exp\left\{-\dfrac{([\text{MONTH}]-6.87)}{7.09}\right\}}\right] + \left[\dfrac{21.86}{1+\exp\left\{-\dfrac{([\text{MONTH}]-88.15)}{26.73}\right\}}\right]$
	B-5b	$\text{VOLRBC}[\text{MONTH}] = \left[\dfrac{4.31}{1+\exp\left\{-\dfrac{([\text{MONTH}]-6.45)}{10.0}\right\}}\right] + \left[\dfrac{26.47}{1+\exp\left\{-\dfrac{([\text{MONTH}]-129.61)}{25.98}\right\}}\right]$
	B-5c	$\text{VOLPLASM}[\text{MONTH}] = \left[\dfrac{6.46}{1+\exp\left\{-\dfrac{([\text{MONTH}]-6.81)}{5.74}\right\}}\right] + \left[\dfrac{8.83}{1+\exp\left\{-\dfrac{([\text{MONTH}]-65.66)}{23.62}\right\}}\right]$
	B-5d	VOLECF[MONTH] = 0.73 * VOLBLOOD[MONTH]
	B-5e	$\text{WTECF}[\text{MONTH}] = 0.73 * \dfrac{\text{VOLBLOOD}[\text{MONTH}]}{10}$
	B-5f	$\text{WTBODY}[\text{MONTH}] = \left[\dfrac{8.375}{1+\exp\left\{-\dfrac{([\text{MONTH}]-3.80)}{3.60}\right\}}\right] + \left[\dfrac{17.261}{1+\exp\left\{-\dfrac{([\text{MONTH}]-48.76)}{20.63}\right\}}\right]$

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[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Fluid Volumes and Organ Weights (*continued*)	B-5g	WTBONE[MONTH] = 0.111 * WTBODY[MONTH] [MONTH] ≤12 months = 0.838 + 0.02 * [MONTH] [MONTH] >12 months
	B-5h	WTCORT = 0.8*WTBONE[MONTH]
	B-5i	WTTRAB = 0.2*WTBONE[MONTH]
	B-5j	$\mathrm{WTKIDNEY}\left[\mathrm{MONTH}\right] = \left[\dfrac{0.050}{1+\exp\left\{-\dfrac{\left(\left[\mathrm{MONTH}\right]-5.24\right)}{4.24}\right\}}\right] + \left[\dfrac{0.106}{1+\exp\left\{-\dfrac{\left(\left[\mathrm{MONTH}\right]-65.37\right)}{34.11}\right\}}\right]$
	B-5k	$\mathrm{WTLIVER}\left[\mathrm{MONTH}\right] = \left[\dfrac{0.261}{1+\exp\left\{-\dfrac{\left(\left[\mathrm{MONTH}\right]-9.82\right)}{3.67}\right\}}\right] + \left[\dfrac{0.584}{1+\exp\left\{-\dfrac{\left(\left[\mathrm{MONTH}\right]-55.65\right)}{37.64}\right\}}\right]$
	B-5l	
WTOTHER[MONTH] = WTBODY[MONTH] - WTKIDNEY[MONTH] - WTLIVER[MONTH] - WTTRAB[MONTH] - WTCORT[MONTH] - WTBLOOD[MONTH] - WTECF[MONTH]		
	B-5m	$\mathrm{WTBLOOD}\left[\mathrm{MONTH}\right] = 1.056 * \dfrac{\mathrm{VOLBLOOD}\left[\mathrm{MONTH}\right]}{10}$
		NOTE: The following equations (B-6a to B-6i) represent the correct mathematical specification. These differential equations are translated into difference equations employing the backward Euler solution in the series B-6.5a to B-6.5i (an algebraic rearrangement presented for ease of interpretation). The calculations are shown in B-9a–B9i.
Compartmental Lead Masses (Differential Equations)		

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT

GROUP	NUMBER	EQUATION
	B-6a	dMPLECF(STEPS)/dt = UPTAKE(STEPS) + *INFLOW(STEPS) - OUTFLOW(STEPS)*
Compartmental Lead Masses (Differential Equations) (*continued*)	B-6b	$\mathrm{INFLOW}(\mathrm{STEPS}) = \frac{\mathrm{MLIVER}[\mathrm{STEPS}]}{\mathrm{TLIVPL}[\mathrm{MONTH}]} + \frac{\mathrm{MKIDNEY}[\mathrm{STEPS}]}{\mathrm{TKIDPL}[\mathrm{MONTH}]} + \frac{\mathrm{MOTHER}(\mathrm{STEPS})}{\mathrm{TOTHPL}[\mathrm{MONTH}]} + \frac{\mathrm{MTRAB}(\mathrm{STEPS})}{\mathrm{TTRABPL}[\mathrm{MONTH}]} + \frac{\mathrm{MCORT}[\mathrm{STEPS}]}{\mathrm{TCORTPL}[\mathrm{MONTH}]} + \frac{\mathrm{MRBC}[\mathrm{STEPS}]}{\mathrm{TRBCPL}}$
	B-6c	$\mathrm{OUTFLOW}[\mathrm{STEPS}] = \mathrm{MPLECF}[\mathrm{STEPS}] * \left[\frac{1}{\mathrm{TPLUR}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLLIV}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLKID}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLOTH}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLTRAB}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLCORT}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TPLRBC2}}\right]$
	B-6d	$\frac{\mathrm{dMRBC}[\mathrm{STEPS}]}{\mathrm{dt}} = \left(MRBC[STEPS] + \frac{MPLECF[STEPS]*ns}{TPLRBC2}\right) \Big/ \left(1 + \frac{ns}{TRBCPL}\right)$
	B-6e	$\frac{\mathrm{dMLIVER}[\mathrm{STEPS}]}{\mathrm{dt}} = \frac{\mathrm{MPLECF}[\mathrm{STEPS}]}{\mathrm{TPLLIV}[\mathrm{MONTH}]} - \mathrm{MLIVER}[\mathrm{STEPS}] * \left[\frac{1}{\mathrm{TLIVPL}[\mathrm{MONTH}]} + \frac{1}{\mathrm{TLIVFEC}[\mathrm{MONTH}]}\right]$
	B-6f	$\frac{\mathrm{dMKIDNEY}[\mathrm{STEPS}]}{\mathrm{dt}} = \frac{\mathrm{MPLECF}[\mathrm{STEPS}]}{\mathrm{TPLKID}[\mathrm{MONTH}]} - \frac{\mathrm{MKIDNEY}[\mathrm{STEPS}]}{\mathrm{TKIDPL}[\mathrm{MONTH}]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
	B-6g	$\frac{dMOTHER[STEPS]}{dt} = \frac{MPLECF[STEPS]}{TPLOTH[MONTH]} - MOTHER[STEPS] * \left[\frac{1}{TOTHPL[MONTH]} + \frac{1}{TOTHOUT[MONTH]}\right]$
Compartmental Lead Masses (Differential Equations) (*continued*)	B-6h	$\frac{dMTRAB[STEPS]}{dt} = \frac{MPLECF[STEPS]}{TPLTRAB[MONTH]} - \frac{MTRAB[STEPS]}{TTRABPL[MONTH]}$
	B-6i	$\frac{dMCORT[STEPS]}{dt} = \frac{MPLECF[STEPS]}{TPLCORT[MONTH]} - \frac{MCORT[STEPS]}{TCORTPL[MONTH]}$
	B-6.5a	$\frac{MPLECF[STEPS] - (MPLECF[STEPS] - NS)}{NS} = UPTAKE[MONTH] + INFLOW[STEPS] - OUTFLOW[STEPS]$
	B-6.5b	
	$INFLOW[STEPS] = \frac{MLIVER[STEPS]}{TLIVPL[MONTH]} + \frac{MKIDNEY[STEPS]}{TKIDPL[MONTH]} + \frac{MOTHER[STEPS]}{TOTHPL[MONTH]} + \frac{MTRAB[STEPS]}{TTRABPL[MONTH]} + \frac{MCORT[STEPS]}{TCORTPL[MONTH]} + \frac{MRBC[STEPS]}{TRBCPL}$	
	B-6.5c	
$OUTFLOW[STEPS] = MPLECF[STEPS] * \left[\frac{1}{TPLUR[MONTH]} + \frac{1}{TPLLIV[MONTH]} + \frac{1}{TPLKID[MONTH]} + \frac{1}{TPLOTH[MONTH]} + \frac{1}{TPLTRAB[MONTH]} + \frac{1}{TPLCORT[MONTH]} + \frac{1}{TPLRBC2}\right]$		

<u>Note</u>: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
	B-6.5d	$\frac{\text{MRBC}[\text{STEPS}]-(\text{MRBC}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLRBC2}}-\frac{\text{MRBC}[\text{STEPS}]}{\text{TRBCPL}}$
Compartmental Lead Masses (Differential Equations) (*continued*)	B-6.5e	$\frac{\text{MLIVER}[\text{STEPS}]-(\text{MLIVER}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLLIV}[\text{MONTH}]}-\text{MLIVER}[\text{STEPS}]*\left[\frac{1}{\text{TLIVPL}[\text{MONTH}]}+\frac{1}{\text{TLIVFEC}[\text{MONTH}]}\right]$
	B-6.5f	$\frac{\text{MKIDNEY}[\text{STEPS}]-(\text{MKIDNEY}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLKID}[\text{MONTH}]}-\frac{\text{MKIDNEY}[\text{STEPS}]}{\text{TKIDPL}[\text{MONTH}]}$
	B-6.5g	
	$\frac{\text{MOTHER}[\text{STEPS}]-(\text{MOTHER}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLOTH}[\text{MONTH}]}-\text{MOTHER}[\text{STEPS}]*\left[\frac{1}{\text{TOTHPL}[\text{MONTH}]}+\frac{1}{\text{TOTHOUT}[\text{MONTH}]}\right]$	
	B-6.5h	$\frac{\text{MTRAB}[\text{STEPS}]-(\text{MTRAB}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLTRAB}[\text{MONTH}]}-\frac{\text{MTRAB}[\text{STEPS}]}{\text{TTRABPL}[\text{MONTH}]}$
	B-6.5i	$\frac{\text{MCORT}[\text{STEPS}]-(\text{MCORT}[\text{STEPS}]-\text{NS})}{\text{NS}}=\frac{\text{MPLECF}[\text{STEPS}]}{\text{TPLCORT}[\text{MONTH}]}-\frac{\text{MCORT}[\text{STEPS}]}{\text{TCORTPL}[\text{MONTH}]}$

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[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
		NOTE: Equations B-7b, B-7c, and B-7d represent the distribution of fetal blood lead, derived from the mother's blood lead, at birth. In this simplified form, these equations are numerically equivalent to the following equations that more precisely represent the distribution of lead at birth. The difference in these two sets of equations is insignificant after 2-3 iteration steps.
Tissue Lead Masses and Blood Lead Concentration at Birth		$\mathrm{MPLECF}(0) = \dfrac{\mathrm{PBBLD0} * (\mathrm{VOLPLASM}(0) + \mathrm{VOLRBC}(0)) * \left(\dfrac{\mathrm{TPLRBC}}{\mathrm{NS}}\right)}{\left(\dfrac{\mathrm{TRBCPL}(0)}{\mathrm{NS}}\right)}$
		$\mathrm{MRBC}(0) = \mathrm{PBBLD0} * (\mathrm{VOLPLASM}(0) + \mathrm{VOLRBC}(0)) * \left[1 - 0.416\left(\dfrac{\mathrm{TPLRBC}(0)}{\mathrm{TRBCPL}(0)}\right)\right]$
		$\mathrm{MPLASM}(0) = \dfrac{\mathrm{MPLECF}(0)}{0.416}$
	B-7a	PBBLD0 = 0.85 * PBBLDMAT
	B-7b	$\mathrm{MPLECF}(0) = \dfrac{\mathrm{PBBLD0} * (\mathrm{VOLPLASM}(0) + \mathrm{VOLRBC}(0)) * \left(\dfrac{\mathrm{TPLRBC}}{\mathrm{NS}}\right) * (1.7 - \mathrm{HCT0})}{\left(\dfrac{\mathrm{TRBCPL}(0)}{\mathrm{NS}} + \dfrac{\mathrm{TPLRBC}}{\mathrm{NS}}\right)}$
	B-7c	$\mathrm{MRBC}(0) = \dfrac{\mathrm{PBBLD0} * (\mathrm{VOLPLASM}(0) + \mathrm{VOLRBC}(0)) * \left(\dfrac{\mathrm{TRBCPL}(0)}{\mathrm{NS}}\right)}{\left(\dfrac{\mathrm{TRBCPL}(0)}{\mathrm{NS}} + \dfrac{\mathrm{TPLRBC}}{\mathrm{NS}}\right)}$

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[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT

GROUP	NUMBER	EQUATION
Tissue Lead Masses and Blood Lead Concentration at Birth (*continued*	B-7d	$\mathrm{MPLASM}(0) = \dfrac{\mathrm{MPLECF}(0)}{(1.7 - \mathrm{HCT0})}$
	B-7e	MCORT(0) = 78.9 * PBBLD0 * WTCORT(0)
	B-7f	MKIDNEY(0) = 10.6 * PBBLD0 * WTKIDNEY(0)
	B-7g	MLIVER(0) = 13.0 * PBBLD0 * WTLIVER(0)
	B-7h	MOTHER(0) = 16.0 * PBBLD0 * WTOTHER(0)
	B-7i	MTRAB(0) = 51.2 * PBBLD0 * WTTRAB(0)
	B-8a	$\mathrm{MPLECF}[\mathrm{STEPS}] = \dfrac{\lvert \mathrm{MPLECF}[\mathrm{STEPS} - \mathrm{NS}] + (\mathrm{UPTAKE}[\mathrm{MONTH}]/\mathrm{STEPS}) + \mathrm{SUM3} \rvert}{[1 + (\mathrm{NS} * \mathrm{SUM1}) - (\mathrm{NS} * \mathrm{SUM2})]}$
	B-8b	

$$SUM1[STEPS] = \frac{1}{TPLUR[MONTH]} + \frac{1}{TPLRBC2} + \frac{1}{TPLLIV[MONTH]} + \frac{1}{TPLKID[MONTH]} + \frac{1}{TPLOTH[MONTH]} + \frac{1}{TPLTRAB[MONTH]} + \frac{1}{TPLCORT[MONTH]}$$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm)	B-8c	$SUM2[STEPS] = \frac{1}{TPLRBC2 * \left(\frac{TRBCPL}{NS} + 1\right)} + \frac{1}{TPLLIV[MONTH] * \left(\frac{TLIVPL[MONTH]}{NS} + \frac{TLIVPL[MONTH]}{TLIVALL[MONTH]} + 1\right)} + \frac{1}{TPLKID[MONTH] * \left(\frac{TKIDPL[MONTH]}{NS} + 1\right)} + \frac{1}{\left(\frac{TOTHPL[MONTH]}{NS} + \frac{TOTHPL[MONTH]}{TOTHALL} + 1\right)} + \frac{1}{TPLTRAB[MONTH] * \left(\frac{TTRABPL[MONTH]}{NS} + 1\right)} + \frac{1}{TPLCORT[MONTH] * \left(\frac{TCORTPL[MONTH]}{NS} + 1\right)}$
	B-8d	$SUM3[STEPS] = \frac{MRBC([STEPS] - NS)}{\left(\frac{TRBCPL}{NS} + 1\right)} + \frac{MLIVER([STEPS] - NS)}{\left(\frac{TLIVPL[MONTH]}{NS} + \frac{TLIVPL[MONTH]}{TLIVALL[MONTH]} + 1\right)} + \frac{MKIDNEY([STEPS] - NS)}{\left(\frac{TKIDPL[MONTH]}{NS} + 1\right)} + \frac{MOTHER([STEPS] - NS)}{\left(\frac{TOTHPL[MONTH]}{NS} + \frac{TOTHPL[MONTH]}{TOTHALL} + 1\right)} + \frac{MTRAB([STEPS] - NS)}{\left(\frac{TTRABPL[MONTH]}{NS} + 1\right)} + \frac{MCORT([STEPS] - NS)}{\left(\frac{TCORTPL([MONTH])}{NS} + 1\right)}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm) (*continued*)	B-9a	$$\mathrm{MRBC}\left[\mathrm{STEPS}\right]=\frac{\mathrm{MRBC}\left(\left[\mathrm{STEPS}\right]-\mathrm{NS}\right)+\left[\mathrm{MPLECF}\left[\mathrm{STEPS}\right]*\left(\frac{\mathrm{NS}}{\mathrm{TPLRBC2}}\right)\right]}{\left[1+\frac{\mathrm{NS}}{\mathrm{TRBCPL}}\right]}$$
	B-9b	$$\mathrm{MLIVER}\left[\mathrm{STEPS}\right]=\frac{\mathrm{MLIVER}\left(\left[\mathit{STEPS}\right]-\mathrm{NS}\right)+\left[\mathrm{MPLECF}\left(\left[\mathit{STEPS}\right]\right)*\left(\frac{\mathrm{NS}}{\mathrm{TPLLIV}\left(\left[\mathit{MONTH}\right]\right)}\right)\right]}{\left[1+\frac{\mathrm{NS}}{\mathrm{TLIVALL}\left(\left[\mathit{MONTH}\right]\right)}\right]}$$
	B-9c	$$\mathrm{MKIDNEY}\left[\mathrm{STEPS}\right]=\frac{\mathrm{MKIDNEY}\left(\left[\mathrm{STEPS}\right]-\mathrm{NS}+\left[\mathrm{MPLECF}\left[\mathrm{STEPS}\right]*\left(\frac{\mathrm{NS}}{\mathrm{TPLKID}\left[\mathrm{MONTH}\right]}\right)\right]\right)}{\left[1+\frac{\mathrm{NS}}{\mathrm{TKIDPL}\left[\mathrm{MONTH}\right]}\right]}$$

<u>Note</u>: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm) (*continued*)	B-9d	$\mathrm{MOTHER}\left(\left[\mathit{STEPS}\right]\right)=\dfrac{\mathrm{MOTHER}\left(\left[\mathit{STEPS}\right]-\mathrm{NS}\right)+\left[\mathrm{MPLECF}\left(\left[\mathit{STEPS}\right]\right)*\left(\dfrac{\mathrm{NS}}{\mathrm{TPLOTH}\left(\left[\mathit{MONTH}\right]\right)}\right)\right]}{\left[1+\dfrac{\mathrm{NS}}{\mathrm{TOTHALL}}\right]}$
	B-9e	$\mathrm{MCORT}\left[\mathrm{STEPS}\right]=\dfrac{\mathrm{MTRAB}\left(\left[\mathrm{STEPS}\right]-\mathrm{NS}\right)+\left[\mathrm{MPLECF}\left[\mathrm{STEPS}\right]*\left(\dfrac{\mathrm{NS}}{\mathrm{TPLTRAB}\left[\mathrm{MONTH}\right]}\right)\right]}{1+\dfrac{\mathrm{NS}}{\mathrm{TTRABPL}\left[\mathrm{MONTH}\right]}}$
	B-9f	$\mathrm{MCORT}\left[\mathrm{STEPS}\right]=\dfrac{\mathrm{MCORT}\left(\left[\mathrm{STEPS}\right]-\mathrm{NS}\right)+\left[\mathrm{MPLECF}\left[\mathrm{STEPS}\right]*\left(\dfrac{\mathrm{NS}}{\mathrm{TPLCORT}\left[\mathrm{MONTH}\right]}\right)\right]}{\left[1+\dfrac{\mathrm{NS}}{\mathrm{TCORTPL}\left[\mathrm{MONTH}\right]}\right]}$
	B-9g	$\mathrm{MPLASM}\left[\mathrm{STEPS}\right]=\dfrac{\mathrm{MPLECF}\left[\mathrm{STEPS}\right]*\mathrm{VOLPLASM}\left[\mathrm{MONTH}\right]}{\mathrm{VOLECF}\left[\mathrm{MONTH}\right]+\mathrm{VOLPLASM}\left[\mathrm{MONTH}\right]}$
	B-9h	$\mathit{TOTHALL}=\dfrac{1}{\left[\dfrac{1}{\mathit{TOTHPL}\left[\mathit{MONTH}\right]}+\dfrac{1}{\mathit{TOTHOUT}\left[\mathit{MONTH}\right]}\right]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm) (*continued*)	B-9i	$TLIVALL\left[STEPS\right] = \dfrac{1}{\left[\dfrac{1}{TLIVPL\left[MONTH\right]} + \dfrac{1}{TLIVFEC\left[MONTH\right]}\right]}$
Blood Lead Concentration	B-10a	**NOTE: Equation B-10a is computed by a cumulative loop** $\mathrm{BLOOD}\left[\mathrm{STEPS}\right] = \sum_{1=1}^{\mathrm{STEPS}} \dfrac{\mathrm{MRBC}\left[\mathrm{STEPS}\right] + \mathrm{MPLASM}\left[\mathrm{STEPS}\right]}{\mathrm{VOLBLOOD}\left(\left[\mathrm{MONTH}\right] - 1\right)}$
	B-10b	NS = 1/iterations per day STEPS = 30 / NS = iterations per month
	B-10c	PBBLOODEND([MONTH]) = BLOOD[STEPS]/STEPS

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years; [MONTH] = 0–84; [NS] = iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

APPENDIX B

DATA CROSSWALK FOR THE IEUBKwin MODEL

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The following table contains parameter names and associated values or equations for the Integrated Exposure Uptake and Biokinetic Model for Lead in Children (IEUBK) (versions 1.0 and 1.1). Parameter names are listed alphabetically, with corresponding model components (*e.g.,* exposure). The parameters in italics are user inputs. These parameters are member variables (objects) of a data window in the IEUBKwin model.

The values in the following table are shown with three figures after the decimal point. The IEUBKwin model output is reported to three figures after the decimal except for the blood lead concentration which is reported to one figure after the decimal point. In the IEUBKwin model, the true precision of a calculation is determined by the least precise input value. In addition, for some input parameters, the model will warn users if an input is entered which is not biologically plausible or relevant (*e.g.,* 3 million parts per million [ppm] or -1 ppm).

Data Crosswalk for the IEUBKwin Model				
Component(s)	Parameter Name		Equation No.(s) or Default Values	
	V.1.1	V.1.0	V.1.1	V.1.0
Uptake	ABSD	ABSD	0.300	0.300
Uptake	ABSF	ABSF	0.500	0.500
Uptake	ABSO	ABSO	0.000	0.000
Uptake	ABSS	ABSS	0.300	0.300
Uptake	ABSW	ABSW	0.500	0.500
Exposure	air_absorp[AGE]	air_absorp[AGE]	32.000	32.000
Exposure	air_concentration[AGE]	air_concentration[AGE]	0.100	0.100
Biokinetic	ALLOMET[15]	ALLOMET[15]	0.333	0.333
Uptake	AVD	AVD	1.000	1.000
Uptake	AVF	AVF	1.000	1.000
Exposure	AvgHouseDust	AvgHouseDust	150.000*	150.000*
Exposure	AvgMultiSrc	AvgMultiSrc	150.000	150.000
Uptake	AVINTAKE[MONTH]	UPPOTEN	U-1g–l, U-2	U-1g–l, U-2
Uptake	AVPO	AVP	1.000	1.000
Uptake	AVS	AVS	1.000	1.000
Uptake	AVW	AVW	1.000	1.000
Exposure	beverage[AGE]	beverage[AGE]	E-4d	0.491 0.650 1.170 1.088 0.988 1.023 1.053
Exposure	beverageConc	—	0.002109	—
Exposure	beverage_Consump[AGE]	—	87.993 116.487 209.677 194.982 177.061 183.333 188.710	—
Biokinetic	BLOOD[STEPS]	BLOOD[STEPS]	B-10a,c	B-10a,c
Probability Distribution	blood[t]	blood[t]	None	None
Exposure	bread[AGE]	bread[AGE]	E-4e	0.090 0.286 0.240 0.300 0.360 0.408 0.503

Data Crosswalk for the IEUBKwin Model				
Component(s)	Parameter Name		Equation No.(s) or Default Values	
	V.1.1	V.1.0	V.1.1	V.1.0
Exposure	breadConc	—	0.008927	—
Exposure	bread_Consump[AGE]	—	4.992 15.862 13.311 16.639 19.967 22.629 27.898	—
Exposure	Can_fruit[AGE]	can_fruit[AGE]	E-4f	1.811 1.063 1.058 0.999 0.940 0.969 1.027
Exposure	canFruitConc	—	0.023873	—
Exposure	canFruit_Consump[AGE]	—	13.941 8.183 8.145 7.691 7.236 7.460 7.906	—
Exposure	candy[AGE]	candy[AGE]	E-4h	0.219 0.248 0.724 0.537 0.352 0.326 0.274
Exposure	candyConc	—	0.011554	—
Exposure	Candy_Consump[AGE]	—	9.955 11.273 32.909 24.409 16.000 14.818 12.455	—
Exposure	canVegConc	—	0.004003	—
Exposure	canVeg_Consump[AGE]	—	0.668 2.274 2.563 2.662 2.771 2.626 2.356	—
Biokinetic	CONRBC	CONRBC	1200.000	1200.000

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	*constant_dust_conc[AGE]*	*constant_dust_conc[AGE]*	200.000	200.000
Exposure	*constant_indoor_dust*	*constant_indoor_dust*	200.000	200.000
Exposure	*constant_outdoor_dust*	*constant_outdoor_dust*	200.000	200.000
Exposure	*constant_outdoor_soil*	*constant_outdoor_soil*	200.000	200.000
Exposure	*constant_soil_conc[AGE]*	*constant_soil_conc[AGE]*	200.000	200.000
Exposure	constant_water_conc	constant_water_conc	4.000	4.000
Exposure	contrib_percent	contrib_percent	0.700	0.700
Biokinetic	CRBONEBL[MONTH]	CRBONEBL[MONTH]	B-1h, B-4c	B-1h, B-4c
Biokinetic	CRKIDBL[MONTH]	CRKIDBL[MONTH]	B-2h, B-4a	B-2h, B-4a
Biokinetic	CRLIVBL[MONTH]	CRLIVBL[MONTH]	B-2e,f, B-4b	B-2e,f, B-4b
Biokinetic	CROTHBL[MONTH]	CROTHBL[MONTH]	B-2n,o, B-4d	B-2n,o, B-4d
Exposure	Cutoff	Cutoff	10	10
Exposure	dairy[AGE]	dairy[AGE]	E-4i	0.834 0.705 0.769 0.765 0.762 0.811 0.910
Exposure	dairyConc	—	0.004476	—
Exposure	dairy_Consump[AGE]	—	41.784 35.321 38.527 38.327 38.176 40.631 45.591	—
Exposure	DAYCARE[AGE]	DAYCARE[AGE]	E-9c, E-12c	E-9c, E-12c
Exposure	DaycareConc	DaycareConc	200.000	200.000
Exposure	DaycareFraction	DaycareFraction	0.000	0.000
Exposure	diet_intake[AGE]	diet_intake[AGE]	2.26 1.96 2.13 2.04 1.95 2.05 2.22	5.530 5.780 6.490 6.240 6.010 6.340 7.000
Exposure	DietTotal[AGE]	DietTotal[AGE]	E-4b	E-4b
Biokinetic	DOTHER[0]	DOTHER[0]	None	None
Exposure	dust_indoor[AGE]	dust_indoor[AGE]	200.000	200.000

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	DustTotal[AGE]	DustTotal[AGE]	E-9b, E-10, E-12a–e	E-9b, E-10, E-12a–e
Biokinetic	EXPR[0]	EXPR[0]	None	None
Exposure	f_fruit[AGE]	f_fruit[AGE]	E-4j	0.039 0.196 0.175 0.175 0.179 0.203 0.251
Exposure	fFruitConc	—	0.004462	—
Exposure	fFruit_Consump[AGE]	—	2.495 12.540 11.196 11.196 11.452 12.988 16.059	—
Exposure	FirstDrawConc	FirstDrawConc	4.000	4.000
Exposure	FirstDrawFraction	FirstDrawFraction	0.500	0.500
Exposure	formula[AGE]	formula[AGE]	E-4l	0.340 0.173 0.006 0.000 0.000 0.000 0.000
Exposure	formulaConc	—	0.002433	—
Exposure	formula_Consump[AGE]	—	45.153 22.975 0.797 0.000 0.000 0.000 0.000	—
Exposure	FountainConc	FountainConc	10.000	10.000
Exposure	FountainFraction	FountainFraction	0.150	0.150
Exposure	fruitFraction	fruitFraction	E-5c	E-5c
Exposure	F_veg[AGE]	f_veg[AGE]	E-4k	0.148 0.269 0.475 0.466 0.456 0.492 0.563

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	fVegConc	—	0.006719	—
Exposure	fVeg_Consump[AGE]	—	8.773 15.945 28.156 27.623 27.030 29.164 33.373	—
Probability Distribution	geo_mean	geo_mean	None	None
Probability Distribution	GSD	GSD	—	1.600
Biokinetic	HCT0	HCT0	—	0.450
Exposure	—	home_fruit_consump[AGE]	—	38.481 69.000 63.166 61.672 61.848 67.907 80.024
Exposure	—	home_veg_consump[AGE]	—	56.840 106.500 155.750 157.340 158.930 172.500 199.650
Exposure	HomeFlushedConc	HomeFlushedConc	1.000	1.000
Exposure	HomeFlushedFraction	HomeFlushedFraction	0.000	0.000
Exposure	HouseFraction	HouseFraction	1.000	1.000
Exposure, Uptake	*INAIR[AGE]*	*INAIR[AGE]*	E-3, U-4	E-3, U-4
Exposure	InBeverage[AGE]	InBeverage[AGE]	E-4c, E-5r	E-4c, E-5o
Exposure	InBread[AGE]	InBread[AGE]	E-4c, E-5p	E-4c, E-5m
Exposure	InCandy[AGE]	InCandy[AGE]	E-4c, E-5s	E-4c, E-5p
Exposure	InCanFruit[AGE]	InCanFruit[AGE]	E-4b, E-5g	E-4b, E-5d
Exposure	InCanVeg[AGE]	InCanVeg[AGE]	E-4b, E-5e	E-4b, E-5b
Exposure	InDairy[AGE]	InDairy[AGE]	E-4c, E-5m	E-4c, E-5j
Exposure, Uptake	INDIET[AGE]	INDIET[AGE]	E-4a,b, U-1a,g U-2	E-4a,b, U-1a,g U-2
Exposure	IndoorConc[AGE]	IndoorConc[AGE]	E-1, E-2	E-1, E-2
Exposure	indoorpercent	indoorpercent	30.000	30.000

Data Crosswalk for the IEUBKwin Model				
Component(s)	Parameter Name		Equation No.(s) or Default Values	
	V.1.1	V.1.0	V.1.1	V.1.0
Exposure, Uptake	INDUSTA[AGE]	INDUSTA[AGE]	E-9c, U-1d,j, U-2	E-9c, U-1d,j, U-2
Exposure, Uptake	INDUST[AGE]	INDUST[AGE]	E-9a,b,e U-1c,I, U-2	E-9a,b,e U-1c,I, U-2
Exposure	infant[AGE]	infant[AGE]	E-4m	1.294 0.655 0.016 0.000 0.000 0.000 0.000
Exposure	infantConc	—	0.004047	—
Exposure	infant_Consump[AGE]	—	131.767 66.905 1.634 0.000 0.000 0.000 0.000	—
Exposure	InFish[AGE]	InHomeFish[AGE]	E-4b, E-5k	E-4b, E-5h
Biokinetic	INFLOW[STEPS]	INFLOW[STEPS]	B-6a,b, B-6.5a,b	B-6a,b, B-6.5a,b
Exposure	InFormula[AGE]	InFormula[AGE]	E-4c, E-5u	E-4c, E-5r
Exposure	InFrFruit[AGE]	InFrFruit[AGE]	E-4b, E-5h	E-4b, E-5e
Exposure	InFrVeg[AGE]	InFrVeg[AGE]	E-4b, E-5f	E-4b, E-5c
Exposure	InGame[AGE]	InGame[AGE]	E-4b, E-5l	E-4b, E-5i
Exposure	InHomeFruit[AGE]	InHomeFruit[AGE]	E-4b, E-5i	E-4b, E-5f
Exposure	InHomeVeg[AGE]	InHomeVeg[AGE]	E-4b, E-5j	E-4b, E-5g
Exposure	InInfant[AGE]	InInfant[AGE]	E-4c, E-5v	E-4c, E-5s
Exposure	InJuice[AGE]	InJuice[AGE]	E-4c, E-5n	E-4c, E-5k
Exposure	InMeat[AGE]	InMeat[AGE]	E-4b, E-5d	E-4b, E-5a
Exposure	InNuts[AGE]	InNuts[AGE]	E-4c, E-5o	E-4c, E-5i
Exposure	INOTHER[AGE]	INOTHER[AGE]	0.000	0.000
Exposure	InOtherDiet[AGE][1]	InOtherDiet[AGE]	E-4b,c	E-4b,c
Exposure	InPasta[AGE]	InPasta[AGE]	E-4c, E-5q	E-4c, E-5n
Exposure	InSauce[AGE]	InSauce[AGE]	E-4c, E-5t	E-4c, E-5q
Exposure, Uptake	INSOIL[AGE]	INSOIL[AGE]	E-8a,b, U-1e,k, U-2	E-8a,b, U-1e,k, U-2

[1]Does not actually appear in Windows version source code.

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure, Uptake	INWATER[AGE]	INWATER[AGE]	E-6a,b, U-1b,h, U-2	E-6a,b, U-1b,h, U-2
Exposure	juices[AGE]	juices[AGE]	E-4n	0.049 0.283 0.381 0.381 0.381 0.477 0.667
Exposure	juiceConc	—	0.004292	—
Exposure	juice_Consump[AGE]	—	2.018 11.656 15.692 15.692 15.692 19.646 27.471	—
Biokinetic	KPLECF[0]	KPLECF[0]	-	-
Biokinetic	MCORT[0]	MCORT[0]	B-7e	B-7e
Biokinetic	MCORT[STEPS]	MCORT[STEPS]	B-6b,i, B-6.5b,i, B-7e, B-8d, B-9e,f	B-6b,i, B-6.5b,i, B-7e, B-8d, B-9e,f
Exposure	meat[AGE]	meat[AGE]	E-4o	0.226 0.630 0.811 0.871 0.931 1.008 1.161
Exposure	meatConc	—	0.007822	—
Exposure	meat_Consump[AGE]	—	12.500 29.605 38.111 40.930 43.750 47.368 54.558	—
Exposure	meat_Consump[AGE]	fish[AGE]	12.500 29.605 38.111 40.930 43.750 47.368 54.558	29.551 87.477 95.700 101.570 107.441 111.948 120.961

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	meat_Consump[AGE]	game[t]	12.500 29.605 38.111 40.930 43.750 47.368 54.558	29.551 87.477 95.700 101.570 107.441 111.948 120.961
Exposure	meatFraction	meatFraction	E-5a	E-5a
Biokinetic	MKIDNEY[0]	MKIDNEY[0]	B-7f	B-7f
Biokinetic	MKIDNEY[STEPS]	MKIDNEY[STEPS]	B-6b,f, B-6.5b,f, B-7f, B-8d, B-9c	B-6b,f, B-6.5b,f, B-7f, B-8d, B-9c
Biokinetic	MLIVER[0]	MLIVER[0]	B-7g	B-7g
Biokinetic	MLIVER[STEPS]	MLIVER[STEPS]	B-6b,e, B-6.5b,e, B-7g, B-8d, B-9b	B-6b,e, B-6.5b,e, B-7g, B-8d, B-9b
Biokinetic	MOTHER[0]	MOTHER[0]	B-7h	B-7h
Biokinetic	MOTHER[STEPS]	MOTHER[STEPS]	B-6b,g, B-6.5b,g, B-7h, B-8d, B-9d	B-6b,g, B-6.5b,g, B-7h, B-8d, B-9d
Biokinetic	MPLASM[0]	MPLASM[0]	B-7d	B-7d
Biokinetic	MPLASM[STEPS]	MPLASM[STEPS]	B-7d, B-9g, B-10a	B-7d, B-9g, B-10a
Biokinetic	MPLECF[0]	MPLECF[0]	B-7b,d	B-7b,d
Biokinetic	MPLECF[STEPS]	MPLECF[STEPS]	B-6a,c–i, B-6.5a,c–i, B-7b,d, B-8a, B-9a–g	B-6a,c–i, B-6.5a,c–i, B-7b,d, B-8a, B-9a–g
Biokinetic	MRBC[0]	MRBC[0]	B-7c	B-7c
Biokinetic	MRBC[STEPS]	MRBC[STEPS]	B-6b,d, B-6.5b,d, B-7c, B-8d, B-9a, B-10a	B-6b,d, B-6.5b,d, B-7c, B-8d, B-9a, B-10a
Biokinetic	MTRAB[0]	MTRAB[0]	B-7i	B-7i
Biokinetic	MTRAB[STEPS]	MTRAB[STEPS]	B-6b,h, B-6.5b,h, B-7i, B-8d, B-9e	B-6b,h, B-6.5b,h, B-7i, B-8d, B-9e
Exposure	multiply_factor	multiply_factor	—	100.000
Biokinetic	NBCORT	NBCORT	0.400	0.400

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Biokinetic	NBTRAB	NBTRAB	0.200	0.200
Exposure	nuts[AGE]	nuts[AGE]	E-4p	0.0010 0.0110 0.0100 0.0110 0.0110 0.0110 0.0100
Exposure	nutsConc	—	0.005798	—
Exposure	nuts_Consump[AGE]	—	0.087 0.962 0.875 0.962 0.962 0.962 0.875	—
Exposure	OCCUP[AGE]	OCCUP[AGE]	E-9c, E-12a	E-9c, E-12a
Exposure	OccupConc	OccupConc	—	1200.000
Exposure	OccupFraction	OccupFraction	—	0.000
Exposure	OTHER[AGE]	OTHER[AGE]	E-9c, E-12e	E-9c, E-12e
Exposure	OtherConc	OtherConc	—	1200.000
Exposure	OtherFraction	OtherFraction	0.000	0.000
Exposure	other_intake	other_intake	0.000	0.000
Biokinetic	OUTFLOW[STEPS]	OUTFLOW[STEPS]	B-6a,c, B-6.5a,c	B-6a,c, B-6.5a,c
Uptake	PAFD	PAFD	—	0.200
Uptake	PAFF	PAFF	—	0.200
Uptake	PAFP	PAFP	—	0.200
Uptake	PAFS	PAFS	—	0.200
Uptake	PAFW	PAFW	—	0.200
Exposure	pasta[AGE]	pasta[AGE]	E-4q	0.239 0.434 0.603 0.595 0.587 0.623 0.693
Exposure	pastaConc	—	0.006163	—

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	pasta_Consump[AGE]	—	10.409 18.902 26.263 25.915 25.566 27.134 30.183	—
Biokinetic	PBBLD0	PBBLD0	B-7a,b,c,e–i	B-7a,b,c,e–i
Biokinetic	PBBLDMAT	PBBLDMAT	1.0	2.500
Biokinetic	PBBLOODEND[MONTH]	PBBLOODEND[MONTH]	B-10c	B-10c
Biokinetic	RATBLPL	RATBLPL	—	100.000
Biokinetic	RATFECUR	RATFECUR	—	0.750
Biokinetic	RATOUTFEC	RATOUTFEC	—	0.750
Biokinetic	RCORT0	RCORT0	—	78.900
Biokinetic	RECSUM[STEPS]	RECSUM[0]	—	None
Biokinetic	ResCoef[15]	ResCoef[15]	—	0.100 20.000 10.000 10.000 10.000 1.000 100.000 0.750 0.750 0.000 0.000 0.000 0.000 0.000 0.000
Biokinetic	RKIDNEY0	RKIDNEY0	—	10.600
Biokinetic	RLIVER0	RLIVER0	—	13.000
Biokinetic	ROTHER0	ROTHER0	—	16.000
Biokinetic	RTRAB0	RTRAB0	—	51.200
Uptake	SATINTAKE2	SATINTAKE2	—	100.000
Uptake	SATUPTAKE[MONTH]	SATUPTAKE[MONTH]	U-1g–l, U-3	U-1g–l, U-3
Exposure	sauce[AGE]	sauce[AGE]	E-4r	0.021 0.061 0.071 0.088 0.104 0.105 0.105

Data Crosswalk for the IEUBKwin Model				
Component(s)	Parameter Name		Equation No.(s) or Default Values	
	V.1.1	V.1.0	V.1.1	V.1.0
Exposure	sauceConc	—	0.010215	—
Exposure	Sauce_Consump[AGE]	—	1.647 4.784 5.569 6.902 8.157 8.235 8.235	—
Exposure	SCHOOL[AGE]	SCHOOL[AGE]	E-9c, E-12d	E-9c, E-12d
Exposure	SchoolConc	SchoolConc	—	200.000
Exposure	SchoolFraction	SchoolFraction	—	0.000
Exposure	SECHOME[AGE]	SECHOME[AGE]	E-9c, E-12d	E-9c, E-12d
Exposure	SecHomeConc	SecHomeConc	—	200.000
Exposure	SecHomeFraction	SecHomeFraction	—	0.000
Exposure	soil_content[AGE]	soil_content[AGE]	—	200.000
Exposure	soil_indoor[AGE]	soil_indoor[AGE]	E-9b,d, E-11a–d	E-9b,d, E-11a–d
Exposure	soil_ingested[AGE]	soil_ingested[AGE]	—	0.085 0.135 0.135 0.135 0.100 0.090 0.085
Biokinetic	STEPS	STEPS	B-10b	B-10b
Biokinetic	SUM1[STEPS]	SUM1[STEPS]	B-8a,b	B-8a,b
Biokinetic	SUM2[STEPS]	SUM2[STEPS]	B-8a,c	B-8a,c
Biokinetic	SUM3[STEPS]	SUM3[STEPS]	B-8a,d	B-8a,d
Biokinetic	TBLBONE	TBLBONE[MONTH]	B-1e,h, B-2i,k	B-1e,h, B-2i,k
Biokinetic	TBLFEC	TBLFEC[MONTH]	B-1f,g, B-2e,f	B-1f,g, B-2e,f
Biokinetic	TBLKID	TBLKID[MONTH]	B-1d,g B-2g,h	B-1d,g B-2g,h
Biokinetic	TBLLIV	TBLLIV[MONTH]	B-1b, B-2d,e	B-1b, B-2d,e
Biokinetic	TBLOTH	TBLOTH[MONTH]	B-1c, B-2m,n	B-1c, B-2m,n
Biokinetic	TBLOUT	TBLOUT[MONTH]	B-1g, B-2n,o	B-1g, B-2n,o
Biokinetic	TBLUR	TBLUR[MONTH]	B-1a,f, B-2c	B-1a,f, B-2c
Biokinetic	TBONEBL	TBONEBL[MONTH]	B-1h, B-2j,l	B-1h, B-2j,l
Biokinetic	TCORTPL[MONTH]	TCORTPL[MONTH]	B-2l, B-6b,i, B-6.5b,i, B-8c,d, B-9f	B-2l, B-6b,i, B-6.5b,i, B-8c,d, B-9f

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Exposure	time_out[AGE]	time_out[AGE]	—	1.000 2.000 3.000 4.000 4.000 4.000 4.000
Biokinetic	TimeSteps	TimeSteps	—	1/6
Biokinetic	TKIDPL[MONTH]	TKIDPL[MONTH]	B-2h, B-6b,f, B-6.5b,f, B-8c,d, B-9c	B-2h, B-6b,f, B-6.5b,f, B-8c,d, B-9c
Biokinetic	TLIVALL	TLIVALL	B-8c,d, B-9b,i	B-8c,d, B-9b,i
Biokinetic	TLIVFEC[MONTH]	TLIVFEC[MONTH]	B-2e,f, B-4i, B-6e, B-6.5e	B-2e,f, B-4i, B-6e, B-6.5e
Biokinetic	TLIVPL[MONTH]	TLIVPL[MONTH]	B-2e, B-6b,e, B-6.5b,e, B-8c,d, B-9i	B-2e, B-6b,e, B-6.5b,e, B-8c,d, B-9i
Exposure	TotAltSource	TotAltSource	Internal verification of E-9.5	Internal verification of E-9.5
Biokinetic	TOTHALL	TOTHALL[MONTH]	B-8c,d, B-9d,h	B-8c,d, B-9d,h
Biokinetic	TOTHOUT[MONTH]	TOTHOUT[MONTH]	B-2o, B-6g, B-6.5g, B-9h	B-2o, B-6g, B-6.5g, B-9h
Biokinetic	TOTHPL[MONTH]	TOTHPL[MONTH]	B-2n, B-6b,g, B-6.5b,g, B-8c,d, B-9h	B-2n, B-6b,g, B-6.5b,g, B-8c,d, B-9h
Biokinetic	TPLCORT[MONTH]	TPLCORT[MONTH]	B-2k, B-6c,i, B-6.5c,i, B-8b,c, B-9e,f	B-2k, B-6c,i, B-6.5c,i, B-8b,c, B-9e,f
Biokinetic	TPLKID[MONTH]	TPLKID[MONTH]	B-2g, B-6c,f, B-6.5c,f, B-8b,c, B-9c	B-2g, B-6c,f, B-6.5c,f, B-8b,c, B-9c
Biokinetic	TPLLIV[MONTH]	TPLLIV[MONTH]	B-2d, B-6c,e, B-6.5c,e, B-8b,c, B-9b	B-2d, B-6c,e, B-6.5c,e, B-8b,c, B-9b
Biokinetic	TPLOTH[MONTH]	TPLOTH[MONTH]	B-2m, B-6c,g, B-6.5c,g, B-8b,c, B-9d	B-2m, B-6c,g, B-6.5c,g, B-8b,c, B-9d
Biokinetic	TPLRBC	TPLRBC	B-2a,b, B-2.5, B-7b,c	B-2a,b, B-2.5, B-7b,c
Biokinetic	TPLRBC2	TPLRBC2[STEPS]	B-2.5, B-5, B-6c,d, B-6.5c,d, B-8b,c, B-9a	B-2.5, B-5, B-6c,d, B-6.5c,d, B-8b,c, B-9a

Data Crosswalk for the IEUBKwin Model				
Component(s)	**Parameter Name**		**Equation No.(s) or Default Values**	
	V.1.1	**V.1.0**	**V.1.1**	**V.1.0**
Biokinetic	TPLTRAB[MONTH]	TPLTRAB[MONTH]	B-2i, B-6c,h, B-6.5c,h, B-8b,c, B-9e	B-2i, B-6c,h, B-6.5c,h, B-8b,c, B-9e
Biokinetic	TPLUR[MONTH]	TPLUR[MONTH]	B-2c, B-6c, B-6.5c, B-8b	B-2c, B-6c, B-6.5c, B-8b
Biokinetic	TRBCPL	TRBCPL	B-2b, B-6b,d, B-6.5b,d, B-7b,c B-8c,d, B-9a	B-2b, B-6b,d, B-6.5b,d, B-7b,c B-8c,d, B-9a
Biokinetic	TTRABPL[MONTH]	TTRABPL[MONTH]	B-2j, B-6b,h, B-6.5b,h, B-8c,d, B-9e	B-2j, B-6b,h, B-6.5b,h, B-8c,d, B-9e
Exposure	TWA[AGE]	TWA[AGE]	E-2, E-3	E-2, E-3
Uptake	UPAIR[MONTH]	UPAIR[MONTH]	U-4, U-5	U-4, U-5
Uptake	UPDIET[MONTH]	UPDIET[MONTH]	U-1a,g U-5	U-1a,g U-5
Uptake	UPDUSTA[MONTH]	UPDUSTA[MONTH]	U-1d,j, U-5	U-1d,j, U-5
Uptake	UPDUST[MONTH]	UPDUST[MONTH]	U-1c,i U-5	U-1c,i U-5
Uptake	UPOTHER[MONTH]	UPOTHER[MONTH]	U-1f, U-5	U-1f, U-5
Uptake	UPSOIL[MONTH]	UPSOIL[MONTH]	U-1e,k, U-5	U-1e,k, U-5
Biokinetic	UPTAKE[MONTH]	UPTAKE[MONTH]	U-5, B-6a, B-6.5a, B-8a	U-5, B-6a, B-6.5a, B-8a
Uptake	UPWATER[MONTH]	UPWATER[MONTH]	U-1b,h, U-5	U-1b,h, U-5
Exposure	UserFishConc	UserFishConc	—	0.000
Exposure	userFishFraction	userFishFraction	—	0.000
Exposure	UserFruitConc	UserFruitConc	—	0.000
Exposure	userFruitFraction	userFruitFraction	—	0.000
Exposure	UserGameConc	UserGameConc	—	0.000
Exposure	userGameFraction	userGameFraction	—	0.000
Exposure	UserVegConc	UserVegConc	—	0.000
Exposure	userVegFraction	userVegFraction	—	0.000
Exposure	vary_indoor	vary_indoor	—	—
Exposure	vary_outdoor	vary_outdoor	—	—
Exposure	vegFraction	vegFraction	E-5b	E-5b

Data Crosswalk for the IEUBKwin Model				
Component(s)	Parameter Name		Equation No.(s) or Default Values	
	V.1.1	V.1.0	V.1.1	V.1.0
Exposure	vent_rate[AGE]	vent_rate[AGE]	—	2.000 3.000 5.000 5.000 5.000 7.000 7.000
Biokinetic	VOLBLOOD[MONTH]	VOLBLOOD[MONTH]	B-1h, B-2e,f,h,n,o, B-5a,d,e,m, B-10a	B-1h, B-2e,f,h,n,o, B-5a,d,e,m, B-10a
Biokinetic	VOLECF[MONTH]	VOLECF[MONTH]	B-5d, B-9g	B-5d, B-9g
Biokinetic	VOLPLASM[0]	VOLPLASM[0]	B-7b,c	B-7b,c
Biokinetic	VOLPLASM[MONTH]	VOLPLASM[MONTH]	B-5c, B-7b,c, B-9g	B-5c, B-7b,c, B-9g
Biokinetic	VOL	VOLRBC(0)	B-7b,c	B-7b,c
Biokinetic	VOLRBC[MONTH]	VOLRBC[MONTH]	B-2.5, B-5b	B-2.5, B-5b
Exposure	water_consumption[AGE]	water_consumption[AGE]	—	0.200 0.500 0.520 0.530 0.550 0.580 0.590
Exposure	weight_soil	weight_soil	—	45.000
Biokinetic	WTBLOOD[MONTH]	WTBLOOD[MONTH]	B-5l,m	B-5l,m
Uptake, Biokinetic	WTBODY[MONTH]	WTBODY[MONTH]	U-3, B-1a–e, B-5f,g,l	U-3, B-1a–e, B-5f,g,l
Biokinetic	WTBONE[MONTH]	WTBONE[MONTH]	B-5g,h,i	B-5g,h,i
Biokinetic	WTCORT[0]	WTCORT[0]	B-7e	B-7e
Biokinetic	WTCORT[MONTH]	WTCORT[MONTH]	B-1h, B-5h,l, B-7e	B-1h, B-5h,l, B-7e
Biokinetic	WTECF[MONTH]	WTECF[MONTH]	B-5e,l	B-5e,l
Biokinetic	WTKIDNEY[0]	WTKIDNEY[0]	B-7f	B-7f
Biokinetic	WTKIDNEY[MONTH]	WTKIDNEY[MONTH]	B-2h, B-5j,l, B-7f	B-2h, B-5j,l, B-7f
Biokinetic	WTLIVER[0]	WTLIVER[0]	B-7g	B-7g
Biokinetic	WTLIVER[MONTH]	WTLIVER[MONTH]	B-2e,f, B-5k,l, B-7g	B-2e,f, B-5k,l, B-7g
Biokinetic	WTOTHER[0]	WTOTHER[0]	B-7h	B-7h
Biokinetic	WTOTHER[MONTH]	WTOTHER[MONTH]	B-2n,o, B-5l, B-7h	B-2n,o, B-5l, B-7h
Biokinetic	WTTRAB[0]	WTTRAB[0]	B-7i	B-7i
Biokinetic	WTTRAB[MONTH]	WTTRAB[MONTH]	B-1h, B-5i,l, B-7i	B-1h, B-5i,l, B-7i

APPENDIX C

IEUBKwin PARAMETER DICTIONARY

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DESCRIPTION OF PARAMETERS IN THE IEUBKwin MODEL

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
ABSD	Total absorption for dust at low saturation (maximum absorption coefficient, active)	0.300	unitless	0–84	E	Based on U.S. EPA (1989a).	U-1c,d,i,j, U-2
ABSF	Total absorption for food at low saturation (maximum absorption coefficient, active)	0.500	unitless	0–84	E	Based on U.S. EPA (1989a).	U-1a,g, U-2
ABSO	Fraction absorption from paint ingested at low saturation (maximum absorption coefficient, active)	0.000	unitless	0–84	E	Based on the default condition that there is no source of lead paint for ingestion in the household.	U-1f,l, U-2
ABSS	Fraction absorption from soil at low saturation (maximum absorption coefficient, active)	0.300	unitless	0–84	E	Based on U.S. EPA (1989a).	U-1e,k, U-2
ABSW	Total absorption for water at low saturation (maximum absorption coefficient, active)	0.500	unitless	0–84	E	Based on U.S. EPA (1989a).	U-1b,h, U-2
air_absorp[AGE]	Net percentage of lung absorption of air lead	32.000	%	0–84	E	Deposition efficiencies of airborne lead particles were estimated by U.S. EPA (1989a). A respiratory deposition/absorption rate of 25% to 45% is reported for young children living in non-point source areas while a rate of 42% is calculated for those living near point sources. An intermediate value of 32% was chosen.	U-4
air_concentration[AGE]	Outdoor air lead concentration	0.100	$\mu g/m^3$	0–84	E	Based on the lower end of the range 0.1–0.3 μg Pb/m^3 that is reported for outdoor air lead concentration in U.S. cities without lead point sources (U.S. EPA, 1989a).	E-1, E-2, E-11a,b
ALLOMET[15]	Storage array	0.333	unitless	0–84	I	Stores variable and constant values. The exponent, 0.333, in Equations B-1a through B-1e is stored in this array.	B-1a–B-1e
AVD	Fraction available for dust	1.000	unitless	0–84	I	Variable added for later flexibility in describing the absorption process; has no effect in current algorithm.	U-1c,d,i,j
AVF	Fraction available for food/diet	1.000	unitless	0–84	I	Variable added for later flexibility in describing the absorption process; has no effect in current algorithm.	U-1a,g
AvgHouseDust	Average household dust concentration	150.000	µg/g	0–84	I	Value calculated/assigned based on alternate dust lead sources (e.g., day care, sechome, paint, school, and workplace).	—

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
AvgMultiSrc	Multiple Source Analysis average	150.000	µg/g	0–84	I	Based on the contribution of lead from soil, air and alternate indoor sources (such as day care, sechome, paint, school, and workplace).	—
AVINTAKE[MONTH]	Available intake	U-2	µg/day	0–84	I	The amount of lead that is available for intake.	U-1g,h,i,j,k,l, U-2
AVO	Fraction available for paint	1.000	unitless	0–84	I	Variable added for later flexibility in describing the absorption process; has no effect in current algorithm.	U-1f,l
AVS	Fraction available for soil	1.000	unitless	0–84	I	Variable added for later flexibility in describing the absorption process; has no effect in current algorithm.	U-1e,k
AVW	Fraction available for water	1.000	unitless	0–84	I	Variable added for later flexibility in describing the absorption process; has no effect in current algorithm.	U-1b,h
beverage[AGE]	Lead intake from beverages by age	E-4d	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5o
beverageConc	Lead concentration in beverages	0.002109	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4d
beverage_Consump[AGE]	Daily consumption of beverages	87.993 116.487 209.677 194.982 177.061 183.333 188.710	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4d
BLOOD[STEPS]	Blood lead concentration	B-10a,c	µg/dL	0–84	I	Summation variable used to get the average blood lead concentration for monthly period.	B-10a,c

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
bread[AGE]	Lead intake from breads by age	E-4e	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5m
breadConc	Lead concentration in bread	0.008927	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4e
bread_Consump[AGE]	Daily consumption of bread	4.992 15.862 13.311 16.639 19.967 22.629 27.898	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4e
can_fruit[AGE]	Lead intake from canned fruit, when fruit is consumed only in canned form, at age range	E-4f	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5d
canFruitConc	Lead concentration in canned fruit	0.023873	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4f
canFruit_Consump[AGE]	Daily consumption of canned fruit	13.941 8.183 8.145 7.691 7.236 7.460 7.906	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4f

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
can_veg[AGE]	Lead intake from canned vegetables, when vegetable is consumed only in canned form, by age	E-4g	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5b
candy[AGE]	Lead intake from candies by age	E-4h	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5p
candyConc	Lead concentration in candy	0.011554	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4h
candy_Consump[AGE]	Daily consumption of candy	9.955 11.273 32.909 24.409 16.000 14.818 12.455	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4h
canVegConc	Lead concentration in canned vegetables	0.004003	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4g
canVeg_Consump[AGE]	Daily consumption of canned vegetables	0.668 2.274 2.563 2.662 2.771 2.626 2.356	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4g

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
CONRBC	Maximum lead concentration capacity of red blood cells	1200.000	µg/dL	0–84	I	Based on Marcus' (1983) reanalysis of infant baboon data from Mallon (1983). See Marcus (1985a) for assessment of form of relationship and estimates from data on human adults [data from deSilva, 1981a,b; Manton and Malloy, 1983; and Manton and Cook 1984]; and infant and juvenile baboons (Mallon, 1983).	B-2.5
constant_dust_conc[AGE]	Dust lead concentration at age range	200.000	µg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	E-9a, E-11d
constant_indoor_dust	Constant indoor dust lead concentration at age range	200.000	µg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	—
constant_outdoor_dust	Constant outdoor dust lead concentration at age range	200.000	µg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	—
constant_outdoor_soil	Constant outdoor soil lead concentration at age range	200.000	µg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986)	—
constant_soil_conc[AGE]	Soil lead concentration at age range	200.000	µg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	E-8a
constant_water_conc	Water lead concentration at age range	4.000	µg/L	0–84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	E-6a
contrib_percent	Ratio of indoor dust lead concentration to soil lead concentration	0.700	µg/g per µg/g	0–84	E	Analysis of soil and dust data from 1983 East Helena study (U.S. EPA, 1989a). Additional information on this variable can be obtained from the MSD short sheet (EPA 540-F-008, OSWER 9285.7-34 [June 1998]) available on the TRW website.	E-11a,b
CRBONEBL[MONTH]	Ratio of lead concentration (µg/kg) in bone to blood lead concentration (µg/L) at age range	B-4c	L/kg	0–84	I	Data in Barry (1981) were used. Bone lead concentration was calculated as an arithmetic average of the concentrations in the rib, tibia, and calvaria. The blood lead concentrations were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0–12 days, 1–11 mos, 1–5 yrs, 6–9 yrs, 11–16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	B-1h, B-4c

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
CRKIDBL[MONTH]	Ratio of lead concentration (µg/kg) in kidney to blood lead concentration (µgL) at age range	B-4a	L/kg	0−84	I	Data in Barry (1981) were used. Lead concentrations in kidney (combined values for cortex and medulla) and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0−12 days, 1−11 mos, 1−5 yrs, 6−9 yrs, 11−16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	B-2h, B-4a
CRLIVBL[MONTH]	Ratio of lead concentration (µg/kg) in liver to blood lead concentration (µg/L) at age range	B-4b	L/kg	0−84	I	Data in Barry (1981) were used. Lead concentrations in liver and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0−12 days, 1−11 mos, 1−5 yrs, 6−9 yrs, 11−16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	B-2e,f, B-4b
CROTHBL[MONTH]	Ratio of lead concentration (µg/kg) in other soft tissue to blood lead concentration (µg/L) at age range	B-4d	L/kg	0−84	I	Data in Barry (1981) were used. Lead concentration ratio for soft tissues was calculated as a weighted arithmetic average of concentration ratios for muscle (53.8%), fat (24.0%), skin (9.4%), dense connective tissue (4.4%), brain (2.7%), GI tract (2.3%), lung (1.9%), heart (0.7%), spleen (0.3%), pancreas (0.2%), and aorta (0.2%), where the weights applied are given in parentheses. The weight associated with each soft tissue component was equal to the weight of the component (kg) divided by weight of all soft tissues (kg). These weights were estimated from Schroeder and Tipton (1968) and are assumed to apply in the range 0−84 months of age. Concentrations in each of the following eight age groups were considered: stillbirths, 0−12 days, 1−11 mos, 1−5 yrs, 6−9 yrs, 11−16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	B-2n,o, B-4d
Cutoff	Blood lead level of concern	10	µg/dL	0-84	E	USEPA, 1986, 1990; CDC, 1991.	—

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
dairy[AGE]	Lead intake from dairy products by age	E-4i	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5j
dairyConc	Lead concentration in dairy products	0.004476	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4i
dairy_Consump[AGE]	Daily consumption of dairy products	41.784 35.321 38.527 38.327 38.176 40.631 45.591	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4i
DAYCARE[AGE]	Dust lead intake from daycare	E-12c	µg/day	0–84	I	Simple combination of the total amount of dust ingested daily, fraction of total dust ingested as daycare dust, and dust lead concentration at daycare.	E-9c, E-12c
DaycareConc	Dust lead concentration from daycare	200.000	µg/g	0–84	E	Based on the assumption that default daycare dust concentrations are the same as default residence dust concentrations.	E-12c
DaycareFraction	Fraction of total dust ingested daily from daycare dust	0.000	unitless	0–84	E	Based on the default assumption that the child does not attend daycare.	E-9.5, E-12c
diet_intake[AGE]	User-specified diet lead intake by age	2.26 1.96 2.13 2.04 1.95 2.05 2.22	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-4a
DietTotal[AGE]	Total dietary intake at age range	E-4b	µg/day	0–84	I	Sum of all dietary sources; same as INDIET[AGE].	E-4b

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
dust_indoor[AGE]	User-specified indoor dust concentration at age range	200.000	µg/g	0–84	E	Under alternate dust sources model, based on assumption that both soil and outdoor air contribute to indoor dust lead.	E-11c
DustTotal[AGE]	Daily amount of dust ingested at age range	E-10	g/day	0–84	I	Simple combination of total amount of soil and dust ingested daily and fraction of this combined ingestion that is dust alone.	E-9b, E-10, E-12a-e
EXPR[0]	The available capacity of the red blood cells to carry lead; i.e.,1 - lead concentration in RBC at birth	B-7i	unitless	0	I	Calculated value.	B-7i
f_fruit[AGE]	Lead intake from fresh fruit, if no home-grown fruit is consumed, by age	E-4j	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5e
fFruitConc	Lead concentration in fresh fruits	0.004462	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4j
fFruit_Consump[AGE]	Daily consumption of fresh fruit	2.495 12.540 11.196 11.196 11.452 12.988 16.059	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4j
f_veg[AGE]	Lead intake from fresh vegetables, if no home-grown vegetables are consumed, by age	E-4k	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5c
fVegConc	Lead concentration in fresh vegetables	0.006719	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4k

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
fVeg_Consump[AGE]	Daily consumption of fresh vegetables	8.773 15.945 28.156 27.623 27.030 29.164 33.373	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4k
FirstDrawConc	First draw water lead concentration	4.000	µg/L	0–84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989).	E-6b
FirstDrawFraction	Fraction of total water consumed daily as first draw	0.50000	unitless	0–84	E	Conservative value corresponding to consumption largely after four fours stagnation time was used (e.g., early morning or late afternoon).	E-6b, E-7
formula[AGE]	Lead intake from baby formula by age	E-4l	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5r
formulaConc	Lead concentration in formula	0.002433	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4l
formula_Consump[AGE]	Daily consumption of formula	45.153 22.975 0.797 0.000 0.000 0.000 0.000	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4l
FountainConc	Fountain water lead concentration	10.000	µg/L	0–84	E	Default assumption is that the drinking fountain has a lead-lined reservoir, but that consumption is not always first draw. Therefore, a value was selected from the range of 5–25 µg/L.	E-6b
FountainFraction	Fraction of total water consumed daily from water fountains	0.150	unitless	0–84	E	A default value was based on 4–6 trips to the water fountain at 40–50 mL per trip.	E-6b, E-7

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
fruitFraction	Fraction of fruit consumption that is derived from market basket (i.e., total fruit consumption - user-grown)	E-5c	unitless	0-84	E	Calculated value.	E-5g, E-5h
geo_mean	Geometric Mean	—	µg/dL	—	I	Calculated value.	—
GSD	Geometric Standard Deviation	1.600	unitless	0–84	E	U.S. EPA, 1994.	—
HCT0	Hematocrit at birth	0.450	%	0	I	Data from Silve *et al.* (1987); also Spector (1956) and Altman and Dittmer (1973).	B-7b,d
HomeFlushedConc	Home flushed water lead concentration	1.000	µg/L	0–84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989).	E-6b
HomeFlushedFraction	Fraction of home flushed water	0.000	unitless	0–84	E	Based on the assumption that the sum of all residential water fractions cannot exceed 1.	E-6b, E-7
HouseFraction	Fraction of dust exposure that is from residential dust	1.000	unitless	0-84	E	Based on the assumption that the sum of all residential dust fractions cannot exceed 1.	E-9.5, E-9b
INAIR[AGE]	Air lead intake at age range	E-3	µg/day	0–84	I	Product of average air lead concentration and ventilation rate.	E-3, U-4
InBeverage[AGE]	Lead intake from beverages at age range	E-5o	µg/day	0–84	I	Product of total beverage consumed, and the lead concentration in beverage(s).	E-4c, E-5o
InBread[AGE]	Lead intake from bread at age range	E-5m	µg/day	0–84	I	Product of total bread consumed, and the lead concentration in bread(s).	E-4c, E-5m
InCandy[AGE]	Lead intake from candy at age range	E-5p	µg/day	0–84	I	Product of total amount of candy consumed, and the lead concentration in the candy	E-4c, E-5p
InCanFruit[AGE]	Lead intake from canned fruit at age range	E-5d	µg/day	0–84	I	Product of the fraction of non-home grown fruits consumed daily, and lead intake from canned fruits when fruits are consumed only in canned form.	E-4b, E-5d
InCanVeg[AGE]	Lead intake from canned vegetables at age range	E-5b	µg/day	0–84	I	Product of the fraction of vegetables consumed daily as non-home grown, and lead intake from canned vegetables when vegetables are consumed only in canned form.	E-4b, E-5b
InDairy[AGE]	Lead intake from dairy products at age range	E-5j	µg/day	0–84	I	Product of total amount of dairy products consumed, and the lead concentration in the dairy products.	E-4c, E-5j

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
InDairy[AGE]	Lead intake from dairy products by age	E-5m	µg Pb/day	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-4c
INDIET[AGE]	Dietary lead intake at age range	E-4a *or* E-4b	µg/day	0–84	I	Two options are provided. Default option - Considers composite diet lead intake. Alternate option - Combines lead intake from several individual components of diet.	E-4a,b U-1a,g, U-2
IndoorConc[AGE]	Indoor air lead concentration at age range	E-1	µg/m^3	0–84	I	Algebraic expression of relationship.	E-1, E-2
indoorpercent	Ratio of indoor dust lead concentration to corresponding outdoor concentration	30.000	%	0–84	E	Based on homes near lead point sources. The default value is reported in OAQPS (U.S. EPA, 1989a, pp A-1) and is estimated by Cohen and Cohen (1980).	E-1
INDUST[AGE]	Household dust lead intake at age range	E-9a *or* E-9b,d	µg/day	0–84	I	Two options are provided. Default option - Assumes that all dust lead exposure is from the household. Alternate option - Considers dust lead exposure from several alternative sources as well.	E-9a,b,e U-1c,i, U-2
INDUSTA[AGE]	Lead intake from alternate dust sources at age range	E-9c *or* E-9d	µg/day	0–84	I	Two options are provided. Default option - Assumes that lead intake from alternate sources is zero. Alternate option - Combines lead intake from several alternate sources.	E-9c U-1d,j, U-2
infant[AGE]	Lead intake from infant food by age	E-4m	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5s

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
infantConc	Concentration of lead in infant food	0.004047	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4m
infant_Consump[AGE]	Daily consumption of infant (baby) food	131.767 66.905 1.634 0.000 0.000 0.000 0.000	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4m
InFish[AGE]	Lead intake from fish at age range	E-5h	µg/day	0–84	I	Product of total meat consumed daily, fraction of meat consumed a locally caught fish, and lead concentration in fish.	E-4b, E-5k
INFLOW[STEPS]	Lead input to ECF-plasma pool from organs	B-6a,b B-6.5a,b	µg/day	0–84	I	Tissue lead masses and blood lead concentration at birth.	B-6a,b B-6.5a,b
InFormula[AGE]	Lead intake from infant formula at age range	E-5r	µg/day	0–84	I	Product of total infant formula consumed daily, and the lead concentration in the formula.	E-4c, E-5r
InFrFruit[AGE]	Lead intake from non-home grown fresh fruits at age range	E-5e	µg/day	0–84	I	Product of the fraction of fruits consumed daily as non-home grown and lead intake from fresh fruits.	E-4b, E-5e
InFrVeg[AGE]	Lead intake from non-home grown fresh vegetables at age range	E-5c	µg/day	0–84	I	Product of the fraction of vegetables consumed daily as non-home grown and lead intake from fresh vegetables.	E-4b, E-5c
InGame[AGE]	Lead intake from game animal meat at age range	E-5i	µg/day	0–84	I	Product of total meat consumed daily, fraction of meat consumed as game animal meat, and lead concentration in game animal meat.	E-4b, E-5i
InHomeFruit[AGE]	Lead intake from home grown fruits at age range	E-5f	µg/day	0–84	I	Product of total amount of fruit consumed daily, fraction of fruit consumed as home grown, and lead concentration in home grown fruit.	E-4b, E-5f
InHomeVeg[AGE]	Lead intake from home grown vegetables at age range	E-5g	µg/day	0–84	I	Product of total amount of vegetable consumed daily, fraction of vegetables consumed as home grown, and lead concentration in home grown vegetables.	E-4b, E-5g
InInfant[AGE]	Lead intake from infant food at age range	E-5s	µg/day	0–84	I	Product of total amount of infant food consumed daily, and the lead concentration in the infant food.	E-4c, E-5s
InJuice[AGE]	Lead intake from juice at age range	E-5k	µg/day	0–84	I	Product of total amount of juice consumed daily, and the lead concentration in juice.	E-4c, E-5k

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
InMeat[AGE]	Lead intake from non-game and non-fish meat at age range	E-5a	µg/day	0–84	I	Product of total amount of meat consumed daily, fraction of meat consumed as non-game and non-fish meat, and lead concentration in non-game and non-fish meat.	E-4b, E-5a
InNuts[AGE]	Lead intake from nuts at age range	E-5l	µg/day	0–84	I	Product of total amount of nuts consumed daily, and the lead concentration in nuts.	E-4c, E-5l
INOTHER[AGE]	Combined other sources of ingested lead, such as paint chips, ethnic medicines, etc., at age range	0.000	µg/day	0–84	I	Assumes no other sources of ingested lead.	U-1d,f,l, U-2
InOtherDiet[AGE]	Combined lead intake from dairy food, juice, nuts, beverage, pasta, bread, sauce, candy, infant and formula food at age range	E-4c	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	Sum of the amounts of lead ingested in food items not substituted by the calculation of exposure to lead in home grown fruits and vegetables, wild game or fish. U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-4b, E-4c
InPasta[AGE]	Lead intake from pasta at age range	E-5n	µg/day	0–84	I	Product of total amount of pasta consumed daily, and the lead concentration in pasta.	E-4c, E-5n
InSauce[AGE]	Lead intake from sauces at age range	E-5q	µg/day	0–84	I	Product of total amount of sauce consumed daily, and the lead concentration in sauce.	E-4c, E-5q
INSOIL[AGE]	Soil lead intake at age range	E-8a,b	µg/day	0–84	I	Simple combination of total amount of soil and dust ingested daily, fraction of this combined ingestion that is soil alone, and lead concentration in soil.	E-8a,b U-1e,k, U-2
INWATER[AGE]	Water lead intake at age range	E-6a *or* E-6b	µg/day	0–84	I	Two options are provided. Default option - Simple combination of water consumed daily and a constant water lead concentration. Alternate option - Water lead concentration depends on contribution from several individual sources of water.	E-6a,b U-1b,h, U-2

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
juices[AGE]	Lead intake from juices by age	E-4n	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5k
juiceConc	Concentration of lead in juice	0.004292	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4n
juice_Consump[AGE]	Daily consumption of juice	2.018 11.656 15.692 15.692 15.692 19.646 27.471	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4n
KPLECF[0]	total elimination rate from ECF-plasma pool	–	unitless	0–84			–
MCORT[STEPS]	Mass of lead in cortical bone at age range (solutions algorithm)	B-7e *and* B-9f	µg	0 *and* 0–84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of cortical bone. Basis for value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3). Both cases above assume that the cortical bone to blood lead concentration ratio is equal to the bone (composite) to blood lead concentration ratio.	B-6b,i, B-6.5b,i, B-7e, B-8d, B-9e,f

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
meat[AGE]	Lead intake from meat if no game meat or fish is consumed at age range	E-4o	µg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-4o, E-5a
meatConc	Concentration of lead in meat	0.007822	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4o
meat_consump[AGE]	Consumption of meat at age range	12.500 29.605 38.111 40.930 43.750 47.368 54.558	g/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	Quantity consumed based on Pennington (1983).	E-5k,l
meatFraction	Fraction of meat consumption that is derived from market basket (i.e., total meat consumption - user-caught fish and game)	E-5a	unitless	0–84	E	Calculated value.	E-5d
MKIDNEY[STEPS]	Mass of lead in kidney at age range (solutions algorithm)	B-7f *and* B-9c	µg	0 *and* 0–84	I	0 months - Simple combination of an assumed kidney to blood lead concentration ratio, blood lead concentration, and weight of kidney. Basis for the value of the kidney to blood lead concentration ratio was human autopsy data (Barry, 1981). 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	B-6b,f, B-6.5b,f, B-7f, B-8d, B-9c
MLIVER[STEPS]	Mass of lead in liver at age range (solutions algorithm)	B-7g *and* B-9b	µg	0 *and* 0–84	I	0 months - Simple combination of an assumed liver to blood lead concentration ratio, blood lead concentration, and weight of the liver. Basis for the value of the liver to blood lead concentration ratio was human autopsy data (Barry, 1981). 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	B-6b,e, B-6.5b,e, B-7g, B-8d, B-9b

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
MOTHER[STEPS]	Mass of lead in soft tissues at age range (solutions algorithm)	B-7h *and* B-9d	µg	0 *and* 0–84	I	0 months - Simple combination of an assumed soft tissue to blood lead concentration ratio, blood lead concentration, and weight of the soft tissues at birth. Basis for the value of soft tissue to blood lead concentration ratio was human autopsy data (Barry *et al.*, 1981), using total lead and total weight of other tissue. 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	B-6b,g, B-6.5b,g, B-7h, B-8d, B-9d
MPLASM[STEPS]	Mass of lead in plasma pool at age range (solutions algorithm)	B-7d *and* B-9g	µg	0 *and* 0–84	I	0 months - Simple combination of the mass of lead in blood and red blood cells. 0–84 months - Based on the assumption that the lead concentration in plasma-extracellular fluid (ECF) is equal to the lead concentration in the plasma.	B-7d, B-9g, B-10a
MPLECF[STEPS]	Mass of lead in plasma-extra-cellular fluid (plasma-ECF) at age range (solutions algorithm)	B-7b *and* B-8a	µg	0 *and* 0–84	I	0 months - Based on two assumptions. (1) masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium, and; (2) lead concentration in the plasma-ECF is equal to lead concentration in the plasma. 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	B-6a,c–i, B-6.5a,c–i, B-7b,d, B-8a, B-9a,b,c,d,e,f,g
MRBC[STEPS]	Mass of lead in red blood cells at age range (solutions algorithm)	B-7c *and* B-9a	µg	0 *and* 0–84	I	0 months - Based on the assumption that the masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium. 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a –B-6i in Table A-3).	B-6b,d, B-6.5b,d, B-7c, B-8d, B-9a, B-10a

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
MTRAB[STEPS]	Mass of lead in trabecular bone at age range (solutions algorithm)	B-7i *and* B-9e	µg	0 *and* 0–84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of trabecular bone. Basis for the value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0–84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a–B-6i in Table A-3). Both cases above assume that trabecular bone to blood lead concentration ratio is equal to bone (composite) to blood lead concentration ratio.	B-6b,h, B-6.5b,h, B-7i, B-8d, B-9e
multiply_factor	Ratio of in-door dust lead concentration to air lead concentration	100.000	µg /g per µg/m^3	0–84	E	Analyses of the 1983 East Helena study (in U.S. EPA, 1989a, Appendix B-8) suggest about 267 µg/g increment of lead in dust for each µg/m³ lead in air. A much smaller factor of 100 µg/g dust lead per µg/m³ is assumed for non-smelter community exposure. [Variable can exceed 100.]	E-11a,b
NBCORT	Variable for tissue lead masses and blood lead concentration at birth	0.400	unitless	0	I	Variable constant.	—
NBTRAB	Variable for tissue lead masses and blood lead concentration at birth	0.200	unitless	0	I	Variable constant.	—
nuts[AGE]	Lead intake from nuts by age	E-4p	mg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5l
nutsConc	Lead concentration in nuts	0.005798	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4p

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
nuts_Consump[AGE]	Daily consumption of nuts	0.087 0.962 0.875 0.962 0.962 0.962 0.875	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4p
NS	Length of time interval in solution algorithm	1/6	days	0–84	E	This user-selectable parameter is available mainly for adjusting the model run time to the speed of the computer. Newer, faster computers can run the model at the shortest timestep (15 min) in less than one minute. The default value, 4 hours, is based on a tradeoff between numerical accuracy of results and computer run-time. Except in the case of extreme exposure scenarios, there is no difference in the numerical accuracy at any user selectable value for timestep.	B-6.5a,d-i, B-7b,c, B-8a,c,d, B-9a-f, B-10b
OCCUP[AGE]	Dust lead intake from secondary occupation at age range	E-12a	Mg/day	0–84	I	Simple combination of amount of dust ingested, fraction of the total dust ingested as secondary occupational dust, and lead concentration in secondary occupational dust.	E-9c, E-12a
OccupConc	Secondary occupation dust lead concentration	1200.000	μg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	E-12a
OccupFraction	Fraction of total dust ingested as secondary occupation dust	0.000	unitless	0–84	E	The default condition is that there is no adult in the residence who works at a lead-related job.	E-9.5, E-12a
OTHER[AGE]	Dust lead intake from other home exposure source at age range	E-12e	Mg/day	0–84	I	e.g., Simple combination of amount of dust ingested daily, fraction of the total dust ingested as lead-based home paint, and lead concentration in lead-based home paint.	E-9c, E-12e
OtherConc	Lead concentration in house dust containing lead based paint	1200.000	μg/g	0–84	E	Air Quality Criteria Document for Lead (U.S. EPA, 1986).	E-12e
OtherFraction	Fraction of total dust ingested that results from lead- based home paint	0.000	unitless	0–84	E	The default is that lead paint is not actively contributing to house dust.	E-9.5 E-12e
other_intake	Lead intake from other media	0	μg/day	0–84	I	User defined.	—
OUTFLOW[STEPS]	Lead output from the ECF-plasma pool from organs	B-6a,c B-6.5a,c	Mg/day	0–84	I	Calculated value.	B-6a,c, B-6.5a,c

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
PAFD PAFF PAFP PAFS PAFW	Fraction of total absorption as passive absorption for dust, diet, paint, soil, and water at low dose	0.200	unitless	0–84	E	Based on in vitro everted rat intestine data (Aungst and Fung, 1981), reanalyses (Marcus, 1994) of infant baboon data (Mallon, 1983), and infant duplicate diet study (Sherlock and Quinn, 1986).	U-1a-l
pasta[AGE]	Lead intake from pasta by age	E-4q	Mg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5n
pastaConc	Concentration of lead in pasta	0.006163	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4q
pasta_Consump[AGE]	Daily consumption of lead	10.409 18.902 26.263 25.915 25.566 27.134 30.183	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4q
PBBLD0	Lead concentration in blood	B-7a	µg/dL	0	I	Based on 85% of maternal blood lead concentration (U.S. EPA, 1989a).	B-7a,b,c, e–i
PBBLDMAT	Maternal blood lead concentration at childbirth	1.0	µg/dL	adult	E	Based on TRW analysis of 1999-2002 NHANES data.	B-7a
PBBLOODEND[MONTH]	Lead concentration in blood at age range	B-10c	µg/dL	0–84	I	Simple combination of the blood lead concentrations determined in each iteration in the solution algorithm between the previous month and that month.	B-10c
RATBLPL	Ratio of lead mass in blood to lead mass in plasma-ECF	100.000	unitless	0–84	I	Based on the lower end of the 50–500 range for the red cell/plasma lead concentration ratio recommended in Diamond and O'Flaherty (1992a).	B-2b–d,g,i,k,m, B-3
RATFECUR	Ratio of endogenous fecal lead elimination rate to urinary lead elimination rate	0.750	unitless	0–84	I	Assume child ratio is larger than the adult ratio; values derived from a reanalysis of data from Ziegler *et al.* (1978) and Rabinowitz and Wetherill (1973).	B-1f

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
RATOUTFEC	Ratio of elimination rate via soft tissues to endogenous fecal lead elimination rate	0.750	unitless	0–84	I	Within the range of values derived from a reanalysis of data from Ziegler *et al.* (1978) and Rabinowitz and Wetherill (1973).	B-1g
RCORT0	Variable for tissue lead masses and blood lead concentration at birth	78.900	unitless	0	I	Variable constant.	–
RECSUM[STEPS]	Lead transfer time from plasma-ECF to all compartments except plasma	–	days	0-84	I	Calculated value	–
ResCoef[15]	Stores parameter values that are used in various equations in the biokinetic module	0.100 20.000 10.000 10.000 10.000 1.000 100.000 0.750 0.750 0.000 0.000 0.000 0.000 0.000 0.000	–		I	Calculated value	B-1a-g; B-2a; B-3
RKIDNEY0	Variable for tissue lead masses and blood lead concentration at birth	10.600	unitless	0	I	Variable constant.	–
RLIVER0	Variable for tissue lead masses and blood lead concentration at birth	13.000	unitless	0	I	Variable constant.	–
ROTHER0	Variable for tissue lead masses and blood lead concentration at birth	16.000	unitless	0	I	Variable constant.	–
RTRAB0	Variable for tissue lead masses and blood lead concentration at birth	51.200	unitless	0	I	Variable constant.	–
SATUPTAKE[MONTH]	Half saturation absorbable lead intake at age range	U-3	Mg/day	0–84	I	Assumed proportional to the weight of body. The coefficient of proportionality is assumed to depend on the estimate of the variable for a 24 month old and the corresponding body weight.	U-1g-l, U-3

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
SATUPTAKE2	Half saturation absorbable lead intake for a 2-year-old	100.000	Mg/day	0–84	E	Extrapolated from reanalysis of human infant data (Sherlock and Quinn, 1986) and infant baboon data (Mallon, 1983).	U-3
sauce[AGE]	Lead intake from sauces by age	E-4r	mg/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	I	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages (May 16, 2006). Available online: http://www.cfsan.fda.gov/~comm/tds-toc.html	E-5q
sauceConc	Concentration of lead in tomato sauce	0.010215	µg/kg	0–84	E	U.S. Food and Drug Administration (FDA). 2006. Total Diet Study.	E-4r
sauce_Consump[AGE]	Daily consumption of tomato sauce	1.647 4.784 5.569 6.902 8.157 8.235 8.235	grams/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Quantity consumed based on Pennington (1983).	E-4r
SCHOOL[AGE]	Dust lead intake from school at age range	E-12b	Mg/day	0–84	I	Simple combination of amount of dust ingested daily, the fraction of total dust ingested daily as school dust, and lead concentration in dust at school.	E-9c, E-12d
SchoolConc	Dust lead concentration at school	200.000	µg/g	0–84	E	By default, this dust lead concentration is set to the same as the residential dust lead concentration.	E-12b
SchoolFraction	Fraction of total dust ingested daily as school dust	0.000	unitless	0–84	E	Based on the default assumption that children are not in school.	E-9.5, E-12b
SECHOME[AGE]	Dust lead intake at secondary home at age range	E-12d	Mg/day	0–84	I	Simple combination of amount of dust ingested daily, fraction of dust ingested daily as secondary home dust, and lead concentration in dust at the secondary home.	E-9c, E-12d
SecHomeConc	Secondary home dust lead concentration	200.000	µg/g	0–84	E	Based on the assumption that dust lead concentration in a secondary home is the same as the default dust lead concentration in the primary home.	E-12d
SecHomeFraction	Fraction of total dust ingested daily as secondary home dust	0.000	unitless	0–84	E	Based on the default assumption that the child does not spend a significant amount of time in a secondary home.	E-9.5, E-12d

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
soil_content[AGE]	Outdoor soil lead concentration	200.000	µg/g	0–84	E	Upper bound value for a plausible urban background soil lead concentration (U.S. EPA, 1989a; HUD, 1990).	E-8b, E-11a
soil_indoor[AGE]	Indoor household dust lead concentration at age range	E-11a–d	µg/g	0–84	E	Under alternate dust sources model, based on assumption that both soil and outdoor air contribute to indoor dust lead.	E-9b,d, E-11a–d
soil_ingested[AGE]	Soil and dust (combined) consumption at age range	0.085 0.135 0.135 0.135 0.100 0.090 0.085	g/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Based on values reported in OAQPS report (U.S. EPA, 1989a, pp. A-16). The values reported were estimated for children, ages 12–48 mos, by several authors such as Binder *et al.* (1986) and Clausing *et al.* (1987). Sedman (1987) extrapolated these estimates to those for children, ages 0–84 months.	E-8a,b, E-9a,d,e, E-10
STEPS	Iterations per month	B-10b	days	—	I	Iteration interval.	B-10b
SUM1[STEPS]	Compartmental lead masses solution algorithm	B-8b	—	0–84	I	For Backward Euler calculation. Intermediate variables for Equations B-8b to B-8d.	B-8a,b
SUM2[STEPS]	Compartmental lead masses solution algorithm	B-8c	—	0–84	I	For Backward Euler calculation. Intermediate variables for Equations B-8b to B-8d.	B-8a,c
SUM3[STEPS]	Compartmental lead masses solution algorithm	B-8d	—	0–84	I	For Backward Euler calculation. Intermediate variables for Equations B-8b to B-8d.	B-8a,d
TBLBONE TBLBONE is not an array	Lead transfer time from blood to bone at age range	B-1e	days	0–84	I	24 months - Initialization is keyed to the 24 month old child, based in part on information from Heard and Chamberlain (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this variable, within a wide range of possible values, has little effect on the blood lead value. 0–84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the variable for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	B-1e,h, B-2i,k

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
TBLFEC TBLFEC is not an array	Lead transfer time from blood to feces at age range	B-1f	days	0–84	I	Simple combination of an assumed ratio of urinary lead elimination rate to endogenous fecal lead elimination rate, and lead transfer time from blood to urine (See RATFECUR). The ratio of elimination rates was estimated for adults using Chamberlain *et al.* (1978) and Chamberlain (1985) and is assumed to apply to ages 0–84 months.	B-1f,g, B-2e,f
TBLKID TBLKID is not an array	Lead transfer time from blood to kidney at age range	10 *and* B-1d	days	0–84	I	24 months - Initialization is keyed to the 24 month old child, based in part on information from Heard and Chamberlain (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this variable, within a wide range of possible values, has little effect on the blood lead value. 0–84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the variable for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	B-1d,g, B-2g,h
TBLLIV TBLLIV is not an array	Lead transfer time from blood to liver at age range	10 *and* B-1b	days	0–84	I	24 months - Initialization is keyed to the 24 month old child, based in part on information from Heard and Chamberlain (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this variable, within a wide range of possible values, has little effect on the blood lead value. 0–84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the variable for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	B-1b, B-2d,e

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
TBLOTH TBLOTH is not an array	Lead transfer time from blood to other soft tissue at age range	10 *and* B-1c	days	0–84	I	24 months - Initialization is keyed to the 24 month old child, based in part on information from Heard and Chamberlain (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this variable, within a wide range of possible values, has little effect on the blood lead value. 0–84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the variable for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	B-1c B-2m,n
TBLOUT TBLOUT is not an array	Lead transfer time from blood to elimination pool via soft tissue at age range	B-1g	days	0–84	I	Simple combination of an assumed ratio of elimination rate via soft tissues to endogenous fecal lead elimination rate, times the lead transfer time from blood to feces (See RATOUTFEC).	B-1g, B-2n,o

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
TBLUR TBLUR is not an array	Lead transfer time from blood to urine at age range	20 *and* B-1a	days	0–84	I	24 months - Assumed proportional to body surface area. The coefficient of proportionality is assumed to depend on an adult estimate for the variable and the corresponding body surface area. The adult estimate of 39 days was obtained using Araki *et al.* (1986a, 1986b, 1987), Assenato *et al.* (1986), Campbell *et al.* (1981), Carton *et al.* (1987), Chamberlain *et al.* (1978), Folashade *et al.* (1991), Heard and Chamberlain (1982), He *et al.* (1988), Kawaii *et al.* (1983), Kehoe (1961), Koster *et al.* (1989), Manton and Malloy (1983), Rabinowitz and Wetherill (1973), Rabinowitz *et al.* (1976), and Yokoyama *et al.* (1985). 0–84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the variable for a 24 month old and the corresponding body surface area. Both cases above assume that (a) body surface area varies as 1/3 power of weight of body based on Mordenti (1986) and (b) respectively, 70 kg and 12.3 kg are standard adult and 24-month-old body weights based on Spector (1956). Since glomerular filtration rate (GFR) is proportional to body surface area for ages ≥24-month based on Weil (1955), surface area scaling is equivalent to scaling by GFR for ages ≥24 months.	B-1a,f, B-2c
TBONEBL TBONEBL is not an array	Lead transfer time from bone to blood at age range	B-1h	days	0–84	I	Based on the assumption that masses of lead in bone and blood are in kinetic quasi-equilibrium.	B-1h, B-2j,l
TCORTPL[MONTH]	Lead transfer time from cortical bone to plasma-ECF at age range	B-2l	days	0–84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months.	B-2l, B-6b,i, B-6.5b,i, B-8c,d, B-9f

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
time_out[AGE]	Time spent outdoors by age	1.000 2.000 3.000 4.000 4.000 4.000 4.000	Hr/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Values are reported in the OAQPS staff report (U.S. EPA, 1989a, p. A-2) and the IEUBK Technical Support Document (U.S. EPA, 1990a). The values have been derived from a literature review (Pope, 1985).	E-2
TKIDPL[MONTH]	Lead transfer time from kidney to plasma-ECF at age range	B-2h	days	0–84	I	Based on the assumption that the lead transfer time from kidney to blood is equal to the lead transfer time from kidney to plasma-ECF.	B-2h, B-6b,f, B-6.5b,f, B-8c,d, B-9c
TLIVALL	Lead transfer time from liver to all tissues for SUM2	B-9i	days	0–84	I	Average transition time from liver to all tissues from SUM2.	B-8c,d, B-9b,i
TLIVFEC[MONTH]	Lead transfer time from liver to feces at age range	B-2e	days	0–84	I	Based on the assumption that the masses of lead in liver and blood are in kinetic quasi-equilibrium.	B-2e,f, B-4i, B-6e, B-6.5e
TLIVPL[MONTH]	Lead transfer time from liver to plasma-ECF at age range	B-2f	days	0–84	I	Based on the assumption that the lead transfer time from liver to blood is equal to the lead transfer time from liver to plasma-ECF.	B-2e, B-6b,e, B-6.5b,e, B-8c,d, B-9i
TotAltSource	Fractional percent due to all secondary sources	None	%	—	I	Total fractional percent due to all secondary sources.	B8c,d B-9d,h
TOTHALL	Lead transfer time from other soft tissues to all tissues for SUM2	B-9h	days	0–84	I	Average transition time from other soft tissues to all tissues from SUM2.	B-8c,d, B-9d,h
TOTHOUT[MONTH]	Lead transfer time from soft tissues to elimination pool at age range	B-2o	days	0–84	I	Based on the assumption that the masses of lead in soft tissues and blood are in kinetic quasi-equilibrium.	B-2o, B-6g, B-6.5g, B-8c,d, B-9h

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
TOTHPL[MONTH]	Lead transfer time from soft tissues to plasma-ECF at age range	B-2n	days	0–84	I	Based on the assumption that the lead transfer time from soft tissues to blood is equal to the lead transfer time from soft tissues to plasma-ECF.	B-2n, B-6b,g, B-6.5b,g, B-8c,d, B-9h
TPLCORT[MONTH]	Lead transfer time from plasma-ECF to cortical bone at age range	B-2k	days	0–84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate at which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months. The cortical bone is 80% of the weight of bone based on Leggett *et al.* (1982).	B-2k, B-6c,i, B-6.5c,i, B-8b,c, B-9e,f
TPLKID[MONTH]	Lead transfer time from plasma-ECF to kidney at age range	B-2g	days	0–84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the kidney is proportional to the rate at which lead leaves the blood to reach the same pool.	B-2g, B-6c,f, B-6.5c,f, B-8b,c, B-9c
TPLLIV[MONTH]	Lead transfer time from plasma-ECF to liver at age range	B-2d	days	0–84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the liver is proportional to the rate at which lead leaves the blood to reach the same pool.	B-2d, B-6c,e, B-6.5c,e, B-8b, B-9b
TPLOTH[MONTH]	Lead transfer time from plasma-ECF to soft tissues at age range	B-2m	days	0–84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the soft tissues is proportional to the rate which lead leaves the blood to reach the same pool.	B-2m, B-6c,g, B-6.5c,g, B-8b,c, B-9d
TPLRBC	Lead transfer time from plasma-ECF to red blood cells for SUM2	0.100	days	0–84	I	Initialization value of 0.1 was assigned as plausible nominal value reflecting best professional judgement on appropriate time scale for composite process of transfer of lead through the red blood cell membrane to lead binding components.	B-2a,b, B-2.5, B-7b,c

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
TPLRBC2	Lead transfer time from plasma-ECF to red blood cells constrained by the maximum capacity of red blood cell lead concentration at age range	B-2.5	days	0–84	I	Simple combination of the lead transfer time from plasma-ECF to red blood cells, and the ratio of red blood cell lead concentration to the corresponding maximum concentration. Based on Marcus (1985a) and reanalysis of infant baboon data.	B-2.5, B-6c,d, B-6.5c,d, B-8b,c, B-9a
TPLTRAB[MONTH]	Lead transfer time from plasma-ECF to trabecular bone at age range	B-2i	days	0–84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate at which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics. The trabecular bone is 20% of the weight of bone based on Leggett *et al.* (1982).	B-2i, B-6c,h, B-6.5c,h, B-8b,c, B-9e
TPLUR[MONTH]	Lead transfer time from plasma-ECF to urine at age range	B-2c	days	0–84	I	Based on the assumption that the rate at which lead leaves the plasma-extra-cellular fluid to reach the urine pool is proportional to the rate at which lead leaves the blood to reach the same pool.	B-2c, B-6c, B-6.5c, B-8b
TRBCPL	Lead transfer time from red blood cells to plasma-ECF	B-2b	days	0–84	I	Based on the assumption that the transfer time out of red blood cells is similar at all ages, since mean red cell value is similar.	B-2b, B-6b,d, B-6.5b,d, B-7b,c, B-8c,d, B-9a
TTRABPL[MONTH]	Lead transfer time from trabecular bone to plasma-ECF fluid at age range	B-2j	days	0–84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months.	B-2j, B-6b,h, B-6.5b,h, B-8c,d, B-9e
TWA[AGE]	Time weighted average air lead concentration at age range	E-2	$\mu g/m^3$	0–84	I	Simple combination of outdoor and indoor air lead concentrations and the number of hours spent outdoors.	E-2, E-3
UPAIR[MONTH]	Air lead uptake at age range	U-4	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-4, U-5

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Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
UPDIET[MONTH]	Diet lead uptake at age range	U-1a	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-1a,g, U-5
UPDUSTA[MONTH]	Lead uptake rate from alternate sources at age range	U-1f	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-1d,j, U-5
UPDUST[MONTH]	Dust lead uptake at age range	U-1c	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-1c,i, U-5
UPSOIL[MONTH]	Soil lead uptake at age range	U-1e	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-1e,k, U-5
UPTAKE[MONTH]	Total lead uptake at age range	U-5	µg/mo	0–84	I	Simple combination of the media-specific daily lead uptake rates, translated to a monthly rate.	B-6a, B-6.5a, B-8a, U-5
UPWATER[MONTH]	Water lead uptake at age range	U-1b	Mg/day	0–84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	U-1b,h, U-5
UserFishConc	Lead concentration in fish	0.000	µg/g	0–84	E	Based on the assumption that locally caught fish are consumed µg Pb/g fish as prepared.	E-5h
userFishFraction	Fraction of total meat consumed as fish	0.000	unitless	0–84	E	Based on the assumption that locally caught fish are consumed.	E-5a,h
UserFruitConc	Lead concentration in home grown fruits	0.000	µg/g	0–84	E	Based on the assumption that home grown fruits are consumed µg Pb/g fruit as prepared.	E-5f
userFruitFraction	Fraction of total fruits consumed as home grown fruits	0.000	unitless	0–84	E	Based on the assumption that home grown fruits are consumed.	E-5d,e,f
UserGameConc	Lead concentration in game animal meat	0.000	µg/g	0–84	E	Based on the assumption that game meat is consumed µg Pb/g game as prepared.	E-5i
userGameFraction	Fraction of total meat consumed as game animal meat excluding fish	0.000	unitless	0–84	E	Based on the assumption that game meat is consumed.	E-5a,i
UserVegConc	Lead concentration in home grown vegetables	0.000	µg/g	0–84	E	Based on the assumption that home grown vegetables are consumed µg Pb/g vegetables as prepared.	E-5g
userVegFraction	Fraction of total vegetables consumed as home grown vegetables	0.000	unitless	0–84	E	Based on the assumption that home grown vegetables are consumed.	E-5b,c,g
vary_indoor	Indoor soil lead concentration	—	µg/g	0–84	E	User specified.	—
vary_outdoor	Outdoor soil lead concentration	—	µg/g	0–84	E	User specified.	—

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
vegFraction	Fraction of vegetable consumption that is derived from market basket (i.e., total vegetable consumption - user-grown)	E-5b	unitless	0–84	E	Calculated value.	E-5e, E-5f
vent_rate[AGE]	Ventilation rate at age range	2.000 3.000 5.000 5.000 5.000 7.000 7.000	M^3/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Values are reported in the OAQPS report (U.S. EPA, 1989a, pp. A-3) and the IEUBK Technical Support Document (U.S. EPA 1990a). These estimates are based on body size in combination with smoothed data from Phalen *et al.* (1985).	E-3
VOLBLOOD[MONTH]	Volume of blood at age range	B-5a	dL	0–84	I	Statistical fitting of data from Silve *et al.* (1987), Spector (1956). and Altman and Dittmer (1973)	B-1h, B-2e,f,h,n,o, B-5a,d,e, m, B-10a
VOLECF[MONTH]	Volume of extra-cellular fluid (ECF) at age range	B-5d	dL	0–84	I	The volume of extracellular fluid that exchanges rapidly with plasma is estimated to be 73% of the blood volume based on Rabinowitz (1976). This additional volume of distribution is assumed to be the volume of the extra-cellular fluid pool, which is the difference between the volume of the distribution and the blood volume.	B-5d, B-9g
VOLPLASM[MONTH]	Volume of plasma at age range	B-5c	dL	0–84	I	Statistical fit to VOLBLOOD(MONTH) - VOLRBC(MONTH)	B-5c, B-7b,c, B-9g
VOLRBC[MONTH]	Volume of red blood cells at age range	B-5b	dL	0–84	I	Statistical fit to hematocrit × blood volume.	B-2.5, B-5b
water_consumption[AGE]	Daily amount of water consumed at age range	0.200 0.500 0.520 0.530 0.550 0.580 0.590	L/day	0–11 12–23 24–35 36–47 48–59 60–71 72–84	E	Exposure Factors Handbook (U.S. EPA, 1989b).	E-6a,b

Note: I = internal model parameter; E = external, user-specified parameter

Parameter Name	Description	Default Value or Equation Number	Units	Age Range (mos)	I or E	Basis for Values/Equations	Equation Where Used
weight_soil	Percentage of total soil and dust ingestion that is soil	45.000	%	0–84	E	IEUBK Guidance Manual, Section 2.3 (U.S. EPA, 1994).	E-8a,b, E-9a,d,e, E-10
WTBLOOD[MONTH]	Weight of blood at age range	B-5m	kg	0–84	I	Based on a blood density of 1.056 kg/L (Spector 1956).	B-5l,m
WTBODY[MONTH]	Weight of body at age range	B-5f	kg	0–84	I	Statistical fitting of data from Silve *et al.* (1987); also Spector (1956) and Altman and Dittmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	B-1a–e, B-5f,g,l, U-3
WTBONE[MONTH]	Weight of bone at age range	B-5g	kg	0–84	I	WTBONE[MONTH] = 0.111 * WTBODY[MONTH] [MONTH] ≤12 months = 0.838 + 0.02 * [MONTH]	B-5g–i
WTCORT[MONTH]	Weight of cortical bone at age range	B-5h	kg	0–84	I	Assumed to be 80% of the weight of the bone based on Leggett *et al.* (1982).	B-1h, B-5h,l, B-7e
WTECF[MONTH]	Weight of extra-cellular fluid (ECF) in lead volume distribution at age range	B-5e	kg	0–84	I	Based on an assumed ECF density approximately the same as water, of 1.0 kg/L.	B-5e,l
WTKIDNEY[MONTH]	Weight of kidney at age range	B-5j	kg	0–84	I	Statistical fitting of data from Silve *et al.* (1987); also Spector (1956) and Altman and Dittmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector, 1956).	B-2h, B-5j,l, B-7f
WTLIVER[MONTH]	Weight of liver at age range	B-5k	kg	0–84	I	Statistical fitting of data from Silve *et al.* (1987); also Spector (1956) and Altman and Dittmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector, 1956).	B-2e,f, B-5k,l, B-7g
WTOTHER[MONTH]	Weight of other tissues at age range	B-5l	kg	0–84	I	Simple combination of the weight of body and the weights of kidney, liver, bone, blood, and extra-cellular fluid.	B-2n,o, B-5l, B-7h
WTTRAB[MONTH]	Weight of trabecular bone at age range	B-5i	kg	0–84	I	Assumed to be 20% of the weight of the bone based on Leggett *et al.* (1982).	B-1h,l, B-5i,l, B-7i

Note: I = internal model parameter; E = external, user-specified parameter

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